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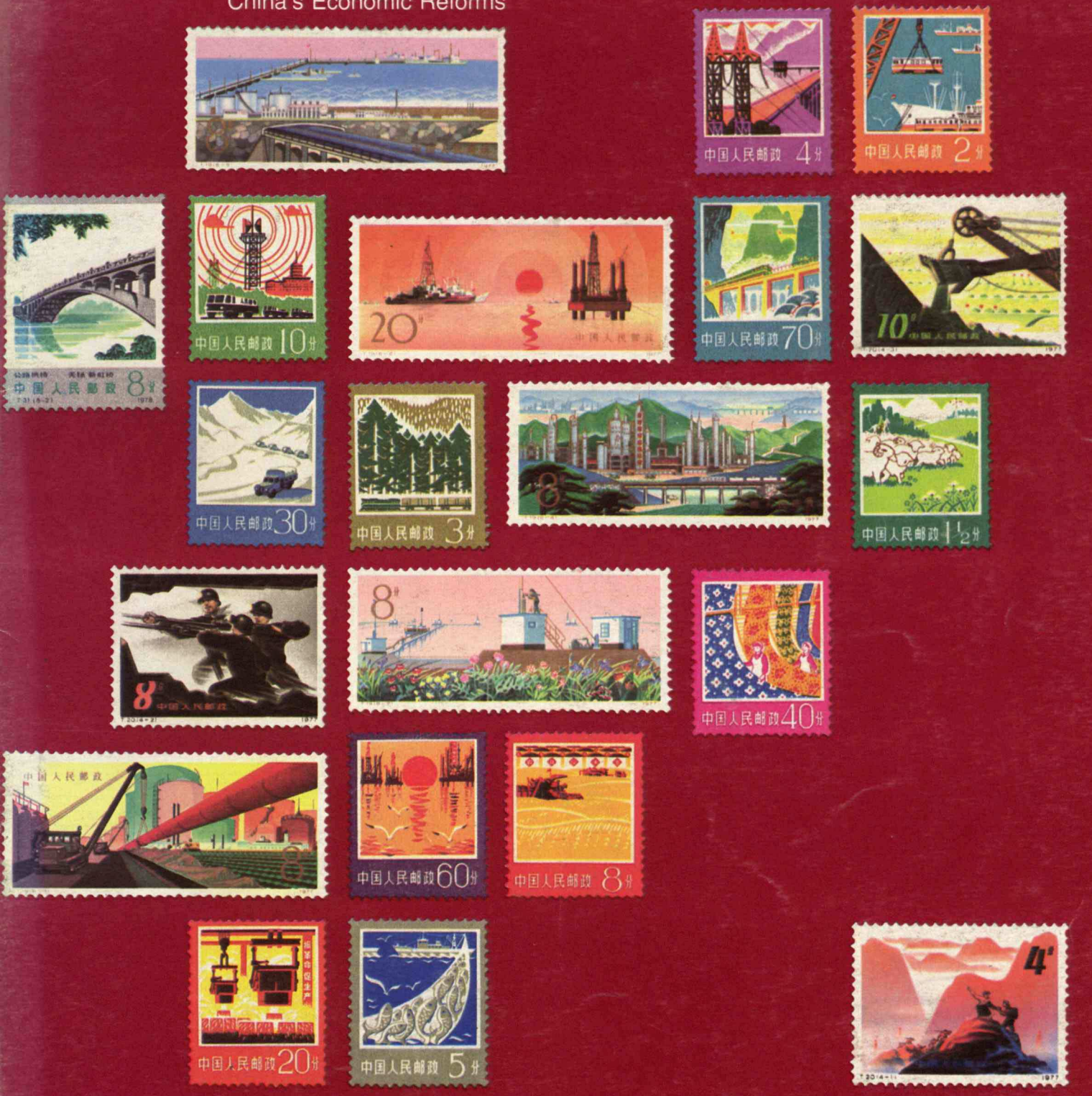
Technology Review

Edited at the Massachusetts Institute of Technology

China's Economic Reforms



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Edited at the Massachusetts Institute of Technology
Volume 82, Number 4
February 1980

Technology Review

FEATURES

China's New Economics
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TREND OF AFFAIRS

COLUMNS

DEPARTMENTS

Engineers to the Rescue

In his review of *Products Liability and the Reasonably Safe Product* (*May, pp. 84-85*), Marshall Burns misses the basic point: apparently the only way to ensure that manufacturers will enlist the services of competent engineers during a product design phase is to make the damage awards large enough so that they become factors in a cost/benefit analysis.

The case of the four-year-old girl able to tip over a 30-inch gas range by stepping on the open oven door is a perfect illustration of my point. Mr. Burns, putting on his somewhat rusty engineering hat, leaped to the conclusion that the only solution would have been to increase the weight of the stove — thereby increasing its cost and decreasing its utility. However, better solutions are available: if the door hinges give way at weights less than required to tip the stove there will be no danger; or a few holes drilled in the rear legs of the stove will allow it to be bolted to the floor.

In almost every case cited by Mr. Burns, the application of a little engineering ingenuity would have greatly increased the safety of the product while reducing the manufacturing cost (or at least not increasing it). As an engineer I naturally approve of this shift in fees from lawyers to engineers. As a consumer I also approve, since I am not convinced that the vast increase in legal and insurance costs have contributed one iota to improved product safety. But little or no money would be spent to engineer safer products unless manufacturers were forced to by government mandate or by large damage awards — or by a combination of the two.
Edwin M. Drogin
Dix Hills, N.Y.

Explanations of the Second Kind

I have done the only comprehensive investigation of the recent U.F.O. sightings off the coast of New Zealand, and my conclusions are somewhat different from those expressed by Robert C. Cowen (*"Explanations of the First Kind," March/April, pp. 10-11*). The weather records for Christchurch do *not* indicate conditions which would be conducive to the trapping of radar or optical electromagnetic radiation, and after my presentation of the evidence the New Zealand Department of Scientific and Industrial Research decided that the film did not show Venus.

Mr. Cowen cited the New Zealand case as an example of the reluctance of the public to accept "rational explanations" for U.F.O. sightings because "it is more fascinating to have a mystery with overtones of extraterrestrial visitation than it is to accept that science has a natural explanation for such things." He might just as well have used it to show the scientific community's reluctance to accept the reality of new macroscopic physical phenomena because of the "overtones of extraterrestrial visitation." This is irrelevant to the question of whether or not something real happened and whether or not it can be explained in a "conventional" manner. The ultimate solution to the real hard-core U.F.O. cases may be so bizarre that no one has even suggested it.

Whatever the explanation might be, it must fit the facts. If it passes that test it is an "explanation of the *second* kind." But what really matters is the "explanation of the final kind." Until that type of explanation is available I advise science writers to publicize "explanations of the first kind" as the ultimate explanations.
Bruce S. Maccabee
Silver Spring, Md.

The writer is associated with the White Oak Laboratory of the Naval Surface Weapons Center. – Ed.

The Risk in Assessing Risk

Technology Review's mild criticism of the Inhaber energy risk assessment study and your presentation of a graph from it (*see "The Risks of Risk Assessment," Trend of Affairs, May, p. 82*) leaves the reader with the impression that the conclusions are worthy of attention. In fact, this is a study filled with errors in both the methodology and the data used, as has been attested to in a number of subsequent critiques.
Stuart L. Simon
McLean, Va.

I would almost like to change the first word in the *Review*'s article on Dr. Inhaber's work from "quick" to "quack." I agree that there is risk in assessing risk, but I think there are better founded references to support the thesis.
Alwin B. Newton
York, Pa.

The Review*'s purpose was not to give credence to the study but to point out a crucial omission – that of long-term effects – in the model; and to point out that this omission was enough to invalidate Dr. Inhaber's conclusions. – Ed.*

ALUMNI FLIGHTS ABROAD
1980-1981

A newly-expanded program of travel now offers an even wider choice of journeys to distant and fascinating areas of the world, including for 1980 the islands of the Galapagos, the Nazca Lines and the desert of Peru, the Amazon, the unusual lands of southern India, an expanded program of discovery to the ancient cities of Greece, Asia Minor and the Aegean, new and more extensive itineraries in ancient Egypt and in the Far East and in India and the Himalayas, as well as the ruins of Tiahuanaco in Bolivia and the Stone Age world of New Guinea, the lands of New Zealand and Australia, the islands of the Seychelles, and game-viewing in the wilds of Kenya and Tanzania.

The travel program is a special one for alumni and alumnae of Harvard, Yale, Princeton, M.I.T., Cornell, Univ. of Virginia, and certain other distinguished universities and for members of their families. Now in its 16th year, it is designed for educated and intelligent travelers and planned for persons who might normally prefer to travel independently, visiting distant lands and regions where it is advantageous to travel as a group.

REALMS OF ANTIQUITY: A newly-expanded program of itineraries, ranging from 15 to 35 days, offers an even wider range of the archaelogical treasures of classical antiquity in Greece, Asia Minor and the Aegean, as well as the ancient Greek cities on the island of Sicily, the ruins of Carthage and Roman cities of North Africa, and a comprehensive and authoritative survey of the civilization of ancient Egypt, along the Nile Valley from Cairo and Meidum as far as Abu Simbel near the border of the Sudan. This is one of the most complete and far-ranging programs ever offered to the civilizations and cities of the ancient world, including sites such as Aphrodisias, Didyma, Aspendos, Miletus and the Hittite citadel of Hattusas, as well as Athens, Troy, Mycenae, Pergamum, Crete and a host of other cities and islands of classical antiquity. The programs in Egypt offer an unusually comprehensive and perceptive view of the civilization of ancient Egypt and the antiquities of the Nile Valley, and include as well a visit to the collection of Egyptian antiquities in the British Museum in London, with the Rosetta Stone.

SOUTH AMERICA and THE GALAPAGOS: A choice of itineraries of from 12 to 29 days, including a cruise among the islands of the Galapagos, the jungle of the Amazon, the Nazca Lines and the desert of southern Peru, the ancient civilizations of the Andes from Machu Picchu to Tiahuanaco near Lake Titicaca, the great colonial cities of the conquistadores, the futuristic city of Brasilia, Iguassu Falls, the snow-capped peaks of the Andes and other sights of unusual interest.

EAST AFRICA—KENYA, TANZANIA AND THE SEYCHELLES: A distinctive program of 5 outstanding safaris, ranging in length from 16 to 32 days, to the great wilderness areas of Kenya and Tanzania and to the beautiful islands of the Seychelles. The safari programs are carefully planned and comprehensive and are led by experts on East African wildlife, offering an exceptional opportunity to see and photograph the wildlife of Africa.

THE SOUTH PACIFIC and NEW GUINEA: A primitive and beautiful land unfolds in the 22-day EXPEDITION TO NEW GUINEA, a rare glimpse into a vanishing world of Stone Age tribes and customs. Includes the famous Highlands of New Guinea, with Sing Sings and tribal cultures and customs, and an exploration of the remote tribal villages of the Sepik and Karawari Rivers and the vast Sepik Plain, as well as the North Coast at Madang and Wewak and the beautiful volcanic island of New Britain with the Baining Fire Dancers. To the south, the island continent of Australia and the islands of New Zealand are covered by the SOUTH PACIFIC, 28 days, unfolding a world of Maori villages, boiling geysers, fiords and snow-capped mountains, ski plane flights over glacier snows, jet boat rides, sheep ranches, penguins, the Australian "outback," historic convict settlements from the days of Charles Dickens, and the Great Barrier Reef. Optional visits can also be made to other islands of the southern Pacific, such as Fiji and Tahiti.

CENTRAL ASIA and THE HIMALAYAS: An expanded program of three itineraries, from 24 to 29 days, explores north and central India and the romantic world of the Moghul Empire, the interesting and surprising world of south India, the remote mountain kingdom of Nepal, and the untamed Northwest Frontier at Peshawar and the Punjab in Pakistan. Includes the Khyber Pass, towering Moghul forts, intricately sculptured temples, lavish palaces, historic gardens, the teeming banks of the Ganges, holy cities and picturesque villages, and the splendor of the Taj Mahal, as well as tropical lagoons and canals, ancient Portuguese churches, the snow-capped peaks of the Himalayas along the roof of the world, and hotels which once were palaces of maharajas.

THE FAR EAST: Itineraries which offer a penetrating insight into the lands and islands of the East. THE ORIENT, 30 days, surveys the treasures of ancient and modern Japan, with Kyoto, Nara, Ise-Shima, Kamakura, Nikko, the Fuji-Hakone National Park, and Tokyo. Also included are the important cities of Southeast Asia, from Singapore and Hong Kong to the temples of Bangkok and the island of Bali. A different and unusual perspective is offered in BEYOND THE JAVA SEA, 34 days, a journey through the tropics of the Far East from Manila and the island fortress of Corregidor to headhunter villages in the jungle of Borneo, the ancient civilizations of Ceylon, Batak tribal villages in Sumatra, the tropical island of Penang, and ancient temples in Java and Bali.

Prices range from $2,350 to $3,900 from U.S. points of departure. Air travel is on regularly scheduled flights of major airlines, utilizing reduced fares which save up to $600.00 and more over normal fares. Fully descriptive brochures are available, giving itineraries in detail and listing departure dates, hotels, individual tour rates and other information. For full details contact:

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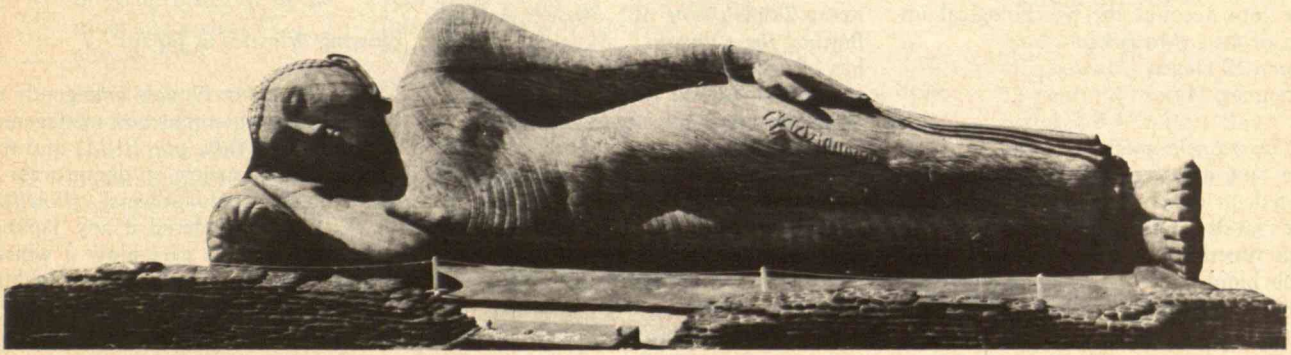


Building a Fusion Future

If, by increasing funding for controlled nuclear fusion development, viable plants for generating power could be on-line by the year 2000, can we afford *not* to take immediate steps to provide this support? Obtaining that support, however, may be a greater challenge than the technological problems themselves: How can we sell a fearful, doubting, resentful, and largely uninformed public on an unproven scientific development program which could fail to meet expectations but which could also succeed in providing vast amounts of low-cost energy on which the nation and the world could flourish? Perhaps readers of the *Review* would comment on the likelihood that, with added public support, the fusion process could be harnessed for energy generation without environmental threat by the year 2000, and on the process by which the necessary public support might be attained.
Robert P. Mason
Alexandria, Va.

The Effects of Research on Research

Your report (*"Lead Poisoning: Is History Repeating Itself?" Trend of Affairs, June/July*) that Dr. Oliver David found behavior problems varied directly and learning progress inversely with levels of lead in children's blood; and that with two months of treatment to remove lead from their bodies 60 to 70 per cent of the children improved in behavior and I.Q. It has long been known that in subjective evaluations both the researchers making inquiries and the evaluators studying the results tend to find what they expect to find. Moreover, more than a generation ago a notable experiment in a Western Electric wiring room demonstrated that the behavior of a group improves if its members know that they are the objects of research. I suspect that the work you report may provide one more illustration of the hazards of scientific research that does not take into account the psychological impact of the research itself.
Everett E. Hagen
Cataumet, Mass.

Dr. David responds:
The screening studies which were reported, in which a relationship between lead levels and various decrements in brain function was demonstrated, were all done blind. That is, none of the raters evaluating a child's functioning had any idea of his/her lead level. Similarly, we took care to avoid the so-called Hawthorne effect and other possible contributors of bias in our treatment studies; they were performed in the context of random-assignment, double-blind, placebo-controlled designs.

Paying Off the Neighbors?

Steven Marcus' cynical editorial questioning of Michael O'Hare's proposal for siting major public facilities (*"Democracy, Nuclear Waste, and a Modest Proposal," Trend of Affairs, Aug./Sept., p. 82*) belies either ignorance of the details of the proposal or malevolence toward the public. The facts simply are that as a society the American people *will* build correctional facilities, nuclear waste storage facilities, nuclear reactors, airports, and a variety of other projects that generally improve the quality of life for most of us but impose risk of unpleasantness on local populations. Traditionally we have told these populations, "Tough luck, folks — we have democratically decided that you must pay for our benefits, and our decision carries the force of law." The real moral question is whether we should continue this patently unjust system for siting major utility and government facilities or should instead implement a proposal that attempts to inject some justice into the system. Professor O'Hare's proposal would do the latter: most of us would have to pay a little more (for energy, airplane travel, or government justice) to obtain the benefit of the facility in question, but local populations would receive compensation for their tolerance of additional risk or noise or environmental unpleasantness. There are questions which must be answered, but the proposal is so much better than our present scheme that these pale to insignificance.
F. Lee Nason
Cambridge, Mass.

The MX System and Arms Reduction

Kosta Tsipis (*"The MX Missile: A Look Beyond the Obvious," May, pp. 55-69*) has clearly merited his reputation as spokesman for the cause of arms reduction. His approach seems to argue that arms reduction is a singularly desirable goal in spite of whatever consequences may ensue. He exhibits willingness to accept the strategic inferiority which could result from the unilateral actions that he proposes as a political, economic, and military necessity.

Dr. Tsipis proposes a limit to long-range ballistic missile testing as a means of slowing down development of new strategic missiles and making the planning of counterforce attack more difficult. But I suggest that orbital — i.e., satellite — testing can be as effective as ballistic testing for determining the performance characteristics of any missile system critical to counterforce capability. The systems which most affect counterforce potential are those that affect accuracy — the guidance and reentry vehicle deployment systems. Tests of these in orbit could be readily disguised as multi-payload satellite system tests, and they would be as valid as tests on a ballistic trajectory. $F = ma$ is a universal phenomenon.

The safe advocacy of unilateral arms reduction figures in Dr. Tsipis' argument for abandoning the current MX development and substituting an undefined, fully mobile, denumerable system. Such a new system would be far longer in development than the MX, which is years from being operational. Thus to argue for a system more complex and less developed than the MX is in fact to argue for unilateral arms reduction.
James F. Fenske
Lexington, Mass.

How Many Earths?

In "The Moons of Jupiter" (*Trend of Affairs, May, pp. 74-79*), Jim Loudon proposes that it may be time to question how common earth-like planets are. I agree, but I do not agree with the inference that they are rare. What we do know now is that each planetary body is the product of the conditions under which it exists. We are entitled to suspect that any given planet is earth-like if it is within a certain range of distances from a reasonably long-lived sun and possesses a satellite of mass roughly proportional to the moon. If it is without a satellite, the planet will probably be Venus-like.
Jerome K. Stephens
Warren, Ohio

Blowing Whistles in Japan?

After reading Mr. Noda's indulgently uncritical article about business management in Japan (*June/July, pp. 20-31*) and then the challenging article on due process for dissenting "whistle-blowers" (*June/July, pp. 48-55*), I wondered if any Japanese subordinate would ever blow a whistle; and, if he did, what would happen to him.
J. B. Lawrence
San Bernardino, Calif.

Will there ever be another TV series as worthwhile as Sesame Street?

Yes, thank goodness. It starts Monday, January 14.

Joan Ganz Cooney and her Children's Television Workshop saw a way 10 years ago to teach kids, using the medium kids love best. The happy result was *Sesame Street*.

Does anyone have to be told *Sesame Street* went on to become one of the most successful TV shows ever?

Now Joan Cooney and the Workshop are ready with a new series every bit as significant as *Sesame Street*. It's called *3-2-1 Contact*. It will be on PBS stations Mondays through Fridays.

3-2-1 Contact is about science. If you just said *ugh*, maybe it's because you grew up without a show like this, which is a pity. And a national problem.

Thousands of bright and inquisitive youngsters start their school years with a natural interest in the sciences. But they get turned off before they ever reach junior high school. Thousands of scientists and engineers are lost to America in the process. *3-2-1 Contact* will keep curiosity alive in 8-to 12-year olds by bringing the same excitement to science and technology that *Sesame Street* brought to the child's first recognition of letters and numbers.

The National Science Foundation, The U.S. Department of Education, and the Corporation for Public Broadcasting all contributed sizable sums to help put *3-2-1 Contact* on the air.

So did we.

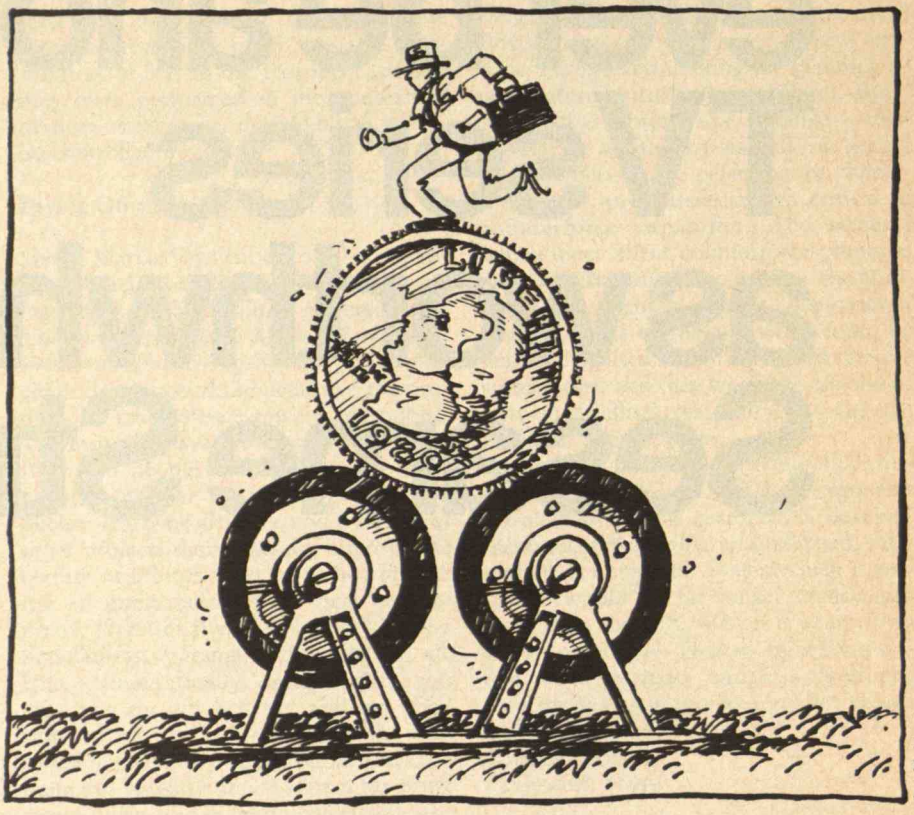
Our motives are simple. We invest more than a million-and-a-half dollars a day in scientific research and development to keep our Otis elevators, Pratt & Whitney Aircraft jet engines, Carrier air conditioners, Sikorsky helicopters and other high-technology products the best in their fields—and to create new and still better products. The United Technologies $2 million grant for this show is part of our investment in the future. We're pleased to make it.

And we're happy to invite you and your 8-to 12-year old friends to watch *3-2-1 Contact*. See your local TV listings for the broadcast schedule.

Hartford, CT 06101

Money Market Madness

Kenneth E. Boulding is director of the Institute of Behavioral Science and emeritus professor of economics at the University of Colorado at Boulder. He is a regular contributor to Technology Review.



Jon McIntosh

The taking of interest has been regarded by moralists as, at best, a necessary evil. This outlook goes back a very long way, at least to Moses and Aristotle, Mohammed and the medieval scholastics, and it culminates with Karl Marx, who regarded it, along with profit, as an unnecessary evil to be done away with by a glorious revolution. Necessary evils, however, seem to stay around for a long time, mainly because getting rid of them often seems to produce worse evils.

The perception of interest as evil unquestionably arises from the perception that the receiver of interest is getting a grant from society for doing very little, except maybe worrying about the security of the loan. The idle rich and the bloated bond-holder have seldom been subject to enthusiastic moral approval.

However, once we accept the institution of property, interest becomes necessary as a social device to reward those who are successful, to allow them to control and use property they do not own, and for others to avoid controlling property they do own. The prime purpose of this financial system is to separate ownership from control.

The division of labor between those who own property but do not want to administer it and those who want to administer it but do not own it is profitable to both parties in comparison with the alternatives, and is, for the most part, advantageous to society. Separation of ownership from control also takes place through the development of corporations, stocks, and the stock market. Here there are ultimate reserves of control, though they are very seldom exercised.

The First Usury Laws

Granted that interest and financial markets are necessary to deal with an otherwise intolerable defect in the system of private property, the question arises: How much interest is necessary? I do not know the date of the first usury laws (I suspect they are very old indeed), but societies have constantly tried to set legal maxima for interest rates. And these legal maxima, if below what would otherwise have been the rate, have also over a long period of time either been evaded or caused trouble — they have prevented arrangements in which both parties felt they would benefit. The strongest case for such legal maxima is in consumption allowances to the poor, where the borrowers are poor and unwary and the lenders rich and clever. It is by no means clear that even this regulation has actually benefitted those for whom it was intended. Nevertheless, there is a strong feeling that interest should be as low as possible without losing benefits. We lose the benefits if interest is so low that those skilled in the use of resources cannot bring them into their hands.

These somewhat arid and abstract considerations suddenly take on new life when the prime rate is in the neighborhood of 15 per cent per annum. When we consider the inflation-unemployment dilemma (perhaps the greatest unsolved problem of open-market societies), the interest problem becomes central. This is because of two fundamental propositions that are obvious when stated but, surprisingly, little understood. First, the real rate of interest is equal to the nominal or contractual rate minus the rate of inflation. If I lend you $100 for one year at 15 per cent, you pay me back $115 next year. If in the meantime the price level has risen 12 per cent, the $115 of next year has the purchasing power of $103. The real interest rate, then, is only about 3 per cent (the mathematics is a little more complex.)

The second proposition is that every time an employer hires an employee for a wage, the employer sacrifices the interest that could have been obtained by lending out the money paid in the wage in hopes of profit on the product of the work for which the wage was paid. The demand for labor, therefore, is a function of the excess of the rate of profit over the rate of interest. In 1932 and 1933, when real interest rates were 3 or 4 per cent and profit rates were about −3 per cent, almost anybody who hired anybody was either a philanthropist, a fool, or a creature of habit. It was only habit that kept the economy going at all. Unemployment was 25 per cent of the labor force; it was surprising that unemployment didn't rise to 75 per cent and the whole economy collapse. Only the hope of holding things together and better times ahead preserved us

from total catastrophe.

The money market situation is complicated by the fact that the rate of profit itself is not independent of interest rates and financial structures, but that is another long and complicated story. What is clear, however, is that if we stopped inflation tomorrow, with contractual interest rates at 15 per cent, we would find ourselves back in 1932 and 1933 and would face a major crisis. Interest rates of 15 per cent are not a cure for inflation; sustained inflation, however, reduces real interest rates to something tolerable. The principal source of inflation is not the financial system but the federal budget deficit, which constantly increases the quantity of money in the possession of the public. This, indeed, is a third proposition — when government takes in $100 and pays out $110, there are $10 more in the pockets of the public. The budget deficit is not, of course, the same as the cash deficit, which is the major source of inflation, but is very closely related.

The acceleration of inflation since 1970 is primarily the result of the disappearance of all taboos on federal deficits and of the rise in contractual interest rates which necessitate continuing the inflation. Inflation, as such, is not primarily the result of the Organization of Petroleum Exporting Countries, the lack of increased productivity, the decline in private savings, or the expansion of bank credit, though all these contribute. Inflation will not be stopped until the federal budget deficit is substantially lowered. The only quick way to do this, in light of the inflexibility of expenditures, is to sharply increase taxes. However, we could easily slide into a deep depression if at the same time interest rates were held at their present height. Financial markets, it may be argued, are flexible and interest rates would adjust.

The difficulty is that long-term financial contracts are hard to adjust. Mortgage rates that seemed reasonable in 1928 were catastrophic in 1932 because of the deflation. These days we are not likely to have deflation, but a cessation of inflation would produce the same effect.

Well, someone will say — and indeed has — if stopping inflation is so difficult, why bother? The simplest way to deal with inflation is to learn to love it. Brazil, after all, has had inflation for 150 years, and it is still alive — though I am not sure everyone would say it is well. This is a tenable viewpoint only if the rate of inflation is held constant. A constant rate of inflation, after all, is only a tax on idle money and on the foolish people who hold it. Taxes on foolishness have always been popular.

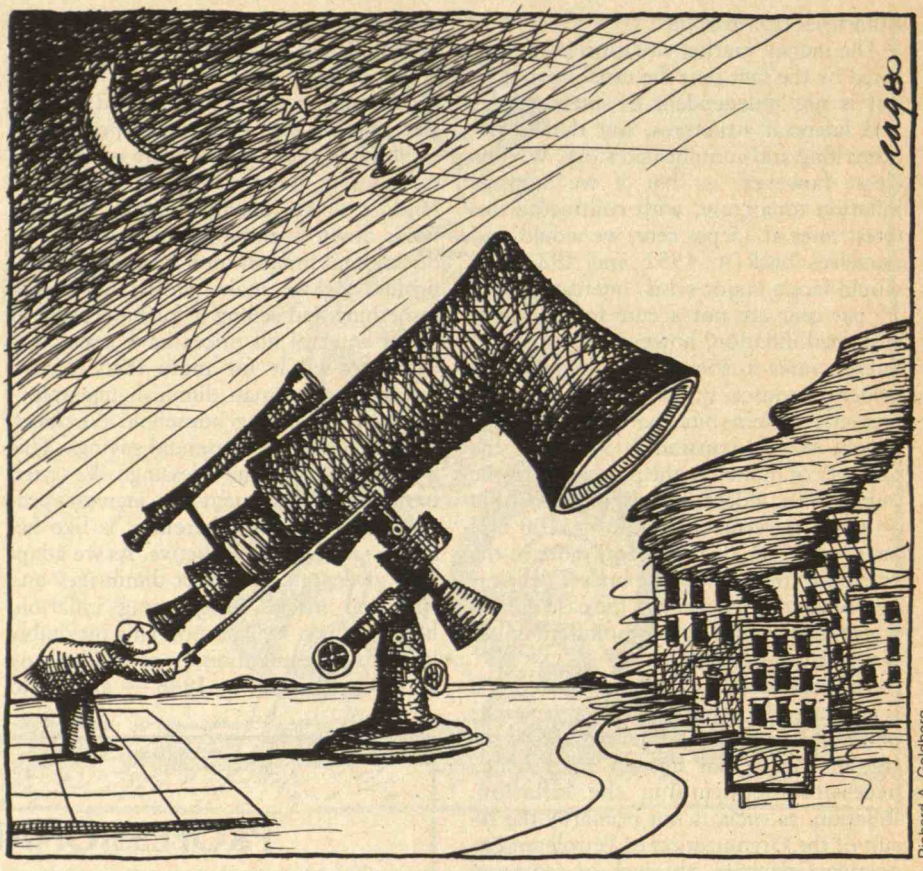
The snag is that it seems hard to hold the inflation rate constant. Once people catch on to the fact that there is inflation, it ceases to do much good in terms of holding down unemployment. Inflation holds down unemployment partly by reducing real interest and creating nominal profits, for we make profits by buying something and selling it for more later. If in the interval all prices have risen, it is easier to sell it for more than it cost. Inflation, also, may diminish unemployment by expanding household purchases at the expense of household savings. This may be a dubious blessing. We need money for investments to increase productivity. Inflation, therefore, is like heroin — it becomes addictive. As we adapt to a given rate, its effect diminishes and we need more. Accelerating inflation, however, is a real no-no. This inevitably leads to hyperinflation — as in Germany in 1932, Hungary in 1946 — and on to real economic collapse.

I propose, therefore, what I call a bold (rather than the Boulding) solution to the present situation — a sudden surcharge on income tax, the size of which would have to be worked out but could easily be 10 per cent, to diminish substantially the budget deficit. I would couple this with a law making all financial contracts invalid unless the interest rate on them is halved, let us say, or reduced an appropriate fraction. There is a precedent for this in the abrogation of the gold clause in 1934, when contracts that had a clause stating that debts had to be paid back in the dollar value of so many ounces of gold were declared invalid by Congress.

My own profession of economics, I regret to say, has played a considerable role in the development of the present crisis. It has been so obsessed with quantification that it has forgotten how to think. And it has forgotten its own history. Almost everything I have said was commonplace 60 years ago and has been forgotten. It is time to remember it again. □

Science and Its Partners in the '80s

Robert C. Cowen, science editor of the Christian Science Monitor, *is former president of the National Association of Science Writers and is a regular contributor to the* Review. *He holds S.B. and S.M. degrees in meteorology from M.I.T.*



Richard A. Goldberg

There's something about the end of a decade that makes "media managers" nostalgic. Across America, editors have been publishing flashbacks and sermonizing on "the lessons of the seventies." Much of their concern is misplaced, for, as always, the main lesson is not that we neglected lessons of the past but that we failed to embark upon the new decade with sufficient foresight. Nevertheless, there are certain "lessons of the seventies" for science and technology that may give us valuable insight for the eighties.

☐ This was the decade when science and technology ceased to be the province of experts. Society at large began to stake a strong claim to share in decisions about goals, allocations, and restraints on scientific technological enterprises.

☐ It also became abundantly clear that the immediate future of humankind lies on this planet. Dreams of space colonies and planetary engineering on Mars have faded before the stark necessity of learning to live together and manage better the limited material resources and environment of an overcrowded world.

☐ Another lesson brought home with a vengeance is that science, especially basic research, must live with a smaller portion of the national pie even in affluent America. Given the demands on resources to develop new energy technologies and the likelihood of continued inflation driven by rising energy costs, the shoe cannot help but pinch more tightly.

These are hardly separate trends. Collectively, they reflect the basic fact that science and technology have become too important to Western society to be left to their own ways. It is useful, however, to consider each trend individually.

The People/Science Connection

To begin with, the American public has not lost faith in the experts. People, by and large, never had the faith that newspapers and television might lead one to think they had — a romantic belief that science and technology are modern miracles that inexorably build a better world. Thus, shocks like a falling *Skylab* or the Three Mile Island reactor accident did not disillusion the public about the experts much as it confirmed an inherent skepticism. Alan McGowan, president of the Scientists' Institute for Public Information, summed it up when he said ". . . The public is smarter than many scientists and engineers think. Many never believed the claims of some that all would be solved by technology. People don't believe in magic." On the other hand, he noted, "Most polls show the scientific community retaining its high standing relative to other groups. . . . Authority of all kinds is in question, but the scientific community least of all. If anything, we have gained a more realistic perception of the costs and benefits of technological society and have realized that technology can only be a tool — albeit essential — in the solution of social problems."

This is the perspective in which to view the interest of some local communities in the regulation of recombinant DNA research, the emergence of strident environmental and "public interest" groups who challenge technological trends, and the rise of "science for the people." Far from being passing aberrations, these are symptoms of a new, healthy involvement of the public in science and technology. If people feel a stake in scientific enterprises and some control over their destinies, then those enterprises will prosper. Only if the public were genuinely alienated would those enterprises be in trouble. This calls for new humility on the part of scientists and engineers and a new willingness to deal honestly with the public.

This means more than trying to communicate expert knowledge simply and clearly. It means recognizing that most people do not automatically share scientists' faith that pursuit of knowledge is a good thing in its own right, nor engineers' faith that equipment will work as designed. I still receive a flood of material from government, industries, and universities that presents scientific and technical subjects as though laypeople were children who had to be entertained rather than adults to be informed. The effectiveness or import of technologies are over-

sold. Vague hypotheses are presented as new scientific insights. And federal research grants are often announced as though the work being funded has already wrought new breakthroughs. When that stuff is fed through the media mill, it's little wonder that science and technology news often sounds like pap.

If the partnership of public and experts —which the public insists be formed — is to be fruitful, more candor is needed. Frank discussions of the limitations and risks, as well as potential benefits, of new technology are needed. Clear delineation between fact and opinion, as well as notation of uncertainties, would be refreshing. Much of the confusion over issues such as control of recombinant DNA, nuclear power, the climatic impact of burning fossil fuels, or ozone versus spray cans has come from "experts" shading the data and softening the uncertainties to fit their viewpoints.

It's also time to soft-pedal the utopian dreams of the big technologists. When the seventies opened, you still heard talk of making deserts bloom with abundant, cheap energy from nuclear power parks. Today, that sounds like a sick joke. The decade also brought visions of self-sustaining colonies in orbit — all "technically feasible over the next few decades." Such notions are good fun and instructive exercises for engineering students. But to push them as serious projects for the eighties or nineties does nothing to help the image of engineers in the minds of laypeople, who know that the number one engineering challenge on the American slate is to make the transition — expeditiously, economically and fairly — from heavy dependence on gas and oil to other energy sources.

Down-to-Earth Technology

Certainly space technology has an important role to play in the coming decades. But that role will be in Earth-oriented applications such as resource and communications satellites, and perhaps manned stations with industrial and research missions. This may sound less than visionary. But there is an urgent need for creative technicians to focus on such overriding problems as energy supply, environmental degradation, and food shortages that yearly press more insistently on humankind in the so-called developed nations and undeveloped nations alike.

This translates directly into an urgent need for scientists and engineers to take a much larger view of their work in relation to society than they have traditionally. Both big and small technology — and middle-sized technology — are needed to help solve problems that involve economic, political, and environmental considerations. The question is not whether "big is ugly," "small is beautiful," or technology is "appropriate." It is whether technologists will be ready for the demanding, often frustrating task of working with critical laypeople to develop what is needed or whether they will try to remain isolated, a luxury I doubt society will allow any longer. Scientists must also fully face the fact that basic science will be on a lean diet indefinitely. This calls for major rethinking of traditional scientific lifestyles if the many promising avenues of new knowledge can be developed.

Shared Research Facilities

First, jobs and incentives for young scientists are important in underfunded fields such as astronomy, space research, and high-energy physics. Concurrent is the question of how best to pursue tantalizing new research opportunities. With high-priority demands on national resources for energy development, the United States will be hard put to maintain a modest program of solar system exploration, support its commitment to the large orbiting telescope and new ground facilities, and complete and operate the particle accelerators. It may be time to internationalize these fields.

Indeed, the costs of some projects have been shared by several nations. Although this might slow the pace of discovery, arguments of national prestige or "falling behind" will cut little ice with the U.S. Congress in the eighties.

Meanwhile, there simply are not enough tenured positions in American universities opening up for the young. There is the nasty choice between trying to persuade older, but still productive, faculty members to give up such positions prematurely and maintaining young scientists in an indefinite postdoctoral holding pattern. I encounter a new reluctance on the part of junior faculty to speak out on controversial matters for fear of jeopardizing their future tenure. And cases of data faking and research fraud are increasing, and motivated by the academic pressure cooker. This problem cannot be solved solely with an influx of new funds. New academic positions need to be created that offer long-term employment in research.

Congress and the funding agencies will be reexamining the role of basic research in American society and how best to support it. Academic scientists should become involved in the discussion and not leave it to the familiar faces at the Congressional hearings. Congressional staffs say this involvement would be refreshing for the committees, and it would be refreshing for reporters, too.

The demand for scientists and engineers to form a new partnership with the public is healthy. At times it may seem like "antiscience" or "antitechnology" sentiments or the threat of "political control of research." But, from the perspective of the nineties, this natural evolution of science and engineering likely will be viewed as a revitalization. □

Technological Detoxification

Joseph Weizenbaum, professor of electrical engineering and computer science at M.I.T., is the author of Computer Power and Human Reason *(Freeman, 1976).* *This essay was prepared for the World Council of Churches' 1979 Conference on Faith, Science, and the Future, and it is reproduced here with the Council's permission.*

In another place — and, it now seems to me, another time — I wrote that "much of what we today regard as good and useful, as well as much of what we would call knowledge and wisdom, we owe to science." I then added: "But science may also be seen as an addictive drug. Not only has our unbounded feeding on science caused us to become dependent on it, but, as happens with many other drugs taken in increasing dosages, science has been gradually converted into a slow-acting poison." Reading these words years after I wrote them, I am now surprised that I didn't take the next obvious step — that is, to talk about our intoxication with science and technology.

The word "intoxication" comes from the Greek "toxicon," which means arrow poison. According to the dictionary, to be intoxicated is to ingest a poison in a dosage sufficient "to excite or stupefy to a point where physical and mental control is markedly diminished." Significantly, the dictionary gives an alternate definition, namely, that to intoxicate is "to excite or elate to the point of enthusiasm or frenzy."

The Thrill of It All

Who can deny that it is precisely excitement, enthusiasm, and especially frenzy that characterize modern Western society's involvement with science and technology? When one recalls the manner in which the United States committed itself to putting a man on the Moon, to name only one example, the characterizations just mentioned leap to mind. It was said that the project would lead to the discovery of crucial secrets which, once unlocked, would lead to the deepest insights into the origin of the universe — that it was, in other words, a search for knowledge for its own sake. In fact, the excitement it generated — which President Kennedy's speech was intended to generate — and the enthusiasm shown by the American public and the technical community had much more to do with the "space race" than with any scientific goals. Moreover, a truly scientific project would have been allowed to set its own pace, allowing thought and reflection to determine intermediate goals and strategies. But the president himself set the frenzied pace when he announced that the intended result would be achieved "within this decade." Another American president, Richard Nixon, greeted astronauts returning from the Moon with the words that this was the most *exciting* moment in his life — as if the purpose of this enormously expensive and dangerous undertaking had been to provide excitement for the people of the United States.

Each day more than a billion dollars are spent worldwide on scientifically refined instruments of death; the United States adds three hydrogen bomb warheads to its arsenal; and in the best-equipped research laboratories of the world young men and women exercise their God-given intelligence and ingenuity to bring the targeting mechanisms of missiles ever closer to perfection. And every now and then America's so-called first lady *christens* — just think what that word means! — a submarine, while her husband boasts that we can wipe out life (though not necessarily property) in every major city in the Soviet Union within a few minutes. Clinical insanity! Utter madness! Who can deny that we are rapidly losing — have perhaps already lost — physical and mental control over our society?

One can be intoxicated — that is, affected by the ingestion of a toxin — without being addicted to that toxin. We can speak of addiction only when the affected organism has undergone physiological changes that cause it to be *dependent* on the toxin. Anyone can get drunk, but not every drunk is an alcoholic. I assert that our society has, in fact, become organically modified by our massive ingestion of the worst fruits of our science and technology. Our loss of control is not momentary, nor is what afflicts us merely a sudden compulsion. The signs of addiction are everywhere around us: massively distorted perceptions of reality abound, and we euphorically embrace every technological fix proffered as a "solution" to every human "problem." The most visible monuments to our world view are our preoccupation with speed, power, and quantity, and— above all — the colossal hubris of much of our scientific community. (Just recall that the "blame" for the recent misadventure of the *Skylab* satellite was pinned on the misbehavior of the sun — too many flares — not on any miscalculation on the part of scientists!) These conditions reflect organic lesions in our society — they are too deep and they have been with us too long to permit us to dismiss them as temporary aberrations.

Real People

The toxin that has invaded us, as seen from the perspective of an information scientist, is fundamentally *abstraction*. To abstract means to draw away from. Science, to function at all, must practice abstraction in that it must necessarily simplify and deal with idealized models — in other words, draw away from reality. And science, idealization, and abstraction are good and useful in proper dosages, when mediated by wisdom gained from many other perspectives. But, beginning roughly at the time of Bacon's observation that knowledge is power, we began to confuse the abstract with the real and then forgot how to make the distinction at all. Our increasing lack of contact with reality is illustrated by the march of abstraction with respect to the products of human labor and to human labor itself. People once traded their labor directly for goods. Then money was introduced as an abstract quantification of human labor. Then checks and other financial instruments became abstractions for money. Now we are approaching the so-called cashless society, in which electrons racing around computers out of reach of human senses become abstractions for financial instruments. An observer from another planet will see people laboring to optimize the paths of electron streams flowing on their behalf in computers unseen and incomprehensible.

Perhaps the most pervasive evidence of the phenomenon I am trying to describe is our substitution of peoples' images for their real persons. This applies not only to individuals — candidates for political offices and other so-called celebrities, for example — but to entire populations. America's war in Vietnam was fought largely to impress various "audiences" — the word comes straight from the Pentagon and from our State Department. The *image* of the United States was at stake, not the lives of real people. An American secretary of "defense" (I put that last

Oren Sherman

word in quotes because it is an Orwellian lie), Melvin Laird, once asserted that American hydrogen bombs were not weapons of destruction but "bargaining chips," of which America had to have a great many so that she could "disarm from a position of strength." This is a logical extension of the well-established military principle that often villages have to be destroyed in order to save them.

Nothing is a more concrete or dangerous manifestation of our confusion of the abstract with the real than the ongoing international arms race. It is perhaps merely a grim joke, but I think it points up a tragic reality, that the foundation of the so-called defense policy of the NATO alliance is officially called MAD, an acronym for "mutual assured destruction." We must withdraw from the myth that ever more numerous powerful weapons of mass destruction offer security to the people of the world. I plead that we stop adding to our already enormous nuclear arsenal — that we begin to *reverse*, not merely to "control," the arms race. My personal position is that the United States ought to begin that process unilaterally.

Salvation of the Human Species

At still another level, the transformation of reality into imagery serves to stupefy the collective consciousness of the people. I have in mind the corruption of everyday language, hence of the creative imaginations of speakers of everyday language, through the illegitimate raising of science-based metaphors to the status of common-sense truths. It is, for example, commonplace to hear of people being programmed. In this way the notion of an abstract machine — one that fascinates the general public almost to the point of hypnotism — becomes that of a human being. And once we accept that human beings are machines, merely symbol manipulators and information processors, then the final step — namely, the deliberate initiation of a program to alter the course of biological evolution in such a way that the human species is replaced by "silicon-based intelligence" — can be announced by the most eminent scientists — for example, Dr. Robert Jastrow, head of NASA's Goddard Space Flight Center. This can be done without alerting anyone that what is being talked about is the death of the human species.

It seems to me obvious that what is now needed is an energetic program — at least for the Western world — of technological detoxification. We must first admit that we are intoxicated with science and technology, that we are deeply committed to a Faustian bargain that is rapidly killing us spiritually and will soon kill us physically. And we must muster the courage and the will to believe that we can recover. We must decide affirmatively to halt the Orwellian corruption of language and gradually wrest ourselves away from the framework of abstractions we have erected. We must live one day at a time in the *real* world, a world peopled by genuine human beings, not images, a world in which word and deed are inherently valued, not the engineered applause of some abstract audience.

As a computer scientist, I am keenly aware of the central role the computer plays in this respect. The computer in our society is in large part a solution in search of problems. The mentality that breeds and nourishes this condition converts human and political problems to technical problems and then proposes technical solutions. One effect of this conversion, not always unintended, is that it distracts attention from real conflicts of interest.

We must begin to assess our situation, and if our assessment reveals technological problems, only then bring our technology to bear. □

Blowing Up More Kilowatts from Wind

American utility companies derived a few hundred kilowatts from the wind last year, and they expect to draw many more soon. In the next 10 years more may be learned about the art of snatching power from the wind than in any previous decade in the 15 centuries that people have built windmills.

When the big Smith-Putnam generator on Granpa's Knob in Vermont was torn down in 1945, most Americans forgot how well it had performed before it lost a blade. Only radio hams and a few folk far from transmission lines continued to derive a few watts from the wind. Even Marcellus Jacobs, who had sold millions of dollars worth of small, three-bladed, electricity-generating windmills, closed his factory and retired to Fort Myers, Fla.

Then, in 1972, as the "energy crisis" began to appear in pessimists' forecasts, William Heronemus, a retired navy captain teaching engineering at the University of Massachusetts, began a campaign for more use of the wind. He proposed a great fleet of wind machines in the Atlantic Ocean off the East Coast, and he's since been called "Captain Windmill" as soaring energy costs have interested more and more people in his ideas.

In 1973 the National Science Foundation and NASA invited a few score early birds in this field to Washington for a workshop on wind energy conversion systems. It was so rewarding that similar pow-wows were held in 1975, 1977, and recently in 1979, where I signed in with nearly 1500 wind power specialists and businesspeople last October. Few if any engineers for utility companies showed up for the 1973 workshop, but that has changed: the industry was well represented last fall. An industry spokesperson reported that 51 utility organizations are now involved in 83 wind projects.

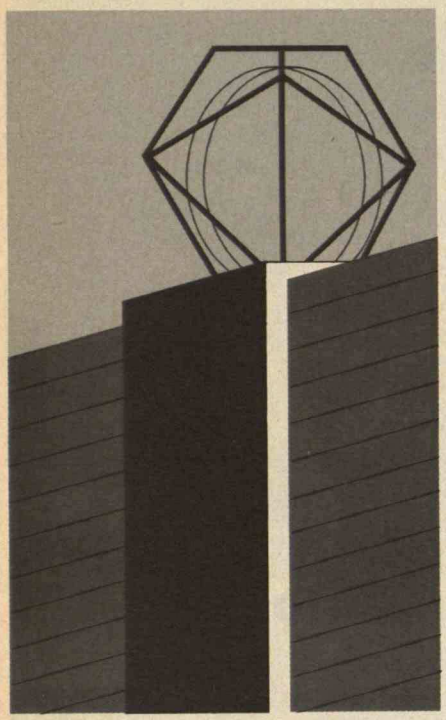
Large wind systems are chiefly the responsibility of NASA's Lewis Research Laboratory at Cleveland, whose engineers hastily put up their first 200-kilowatt machine near Sandusky, Ohio. That one had to be extensively modified before it performed well, but it is still being used to test innovations and components.

Since then three more 200-kilowatt wind turbines, reminiscent of the giant that once stood on Grandpa's Knob, have been erected elsewhere and have performed more satisfactorily. One is at Clayton, N.M.; another is on Culebra, Puerto Rico, an island about 50 miles east of San Juan; and the third is on Block Island, off the Rhode Island coast. This year a fourth 200-kilowatt turbine is to be installed at Oahu, Hawaii.

But these are already dwarfed by the world's largest wind turbine, completed last summer near Boone in the Blue Ridge Mountains of North Carolina. This 2,000-kilowatt giant weighs 650,000 pounds; its 200-foot propeller-type blades are supported by a 140-foot tower and drive a transmission train to spin a generator at 1,800 revolutions per minute.

The next spectacular step will be taken in southern Washington state, about 125 miles east of Portland, where Boeing engineers working for the Bonneville Power Administration will test a cluster of three 2,500-kilowatt wind turbines in a windy gorge of the Columbia River. Such clusters at windy sites have often been hypothesized, but none like this has yet been built. Each unit's rotor will be 300 feet in diameter and begin to turn when the wind reaches 10 miles per hour; the three turbines will produce full power with winds of between 20 and 35 m.p.h.,

A 200-kilowatt experimental wind turbine (opposite) on Block Island off the Rhode Island coast. The Darrieus rotor (below) responds to wind from any direction and is relatively inexpensive to build.



and when the wind blows faster the rotors will stop automatically to avoid overstressing the system. When running full tilt, this cluster will deliver enough current to supply from 2,000 to 3,000 average American homes, and since the average wind speed at this site is 15 m.p.h., that may happen a good part of the time. If mass produced, each such wind turbine would cost a utility company $2,000,000, says Boeing. That's a good deal more than would be needed to build a diesel-powered system of similar capacity, but advocates are quick to point out that the winds don't yield to the whims of OPEC ministers.

Thus far no very grim side effects from big wind-driven generators have been found. They produce no debris. They have not interfered with bird migrations. Their whining need be no more bothersome than that of other machines, and at least to aficionados they enhance the appearance of many landscapes. Some people's reception of television programs has been affected, which may be viewed as a blessing or a curse; if the latter, TV addicts will need cable service.

Toward Bigger Families of Little Fans

Rising energy prices have put a number of entrepreneurs in business making small wind catchers for farmers, ranchers, and homeowners — just as Marcellus Jacobs did two decades ago. Some of these small machines are reminiscent of the world's first windmills (devised to turn millstones) in that their sails (or blades) revolve horizontally around a vertical axis.

A somewhat similar system was tried 50 years ago by George Jean Darrieus, who generated electricity with a wind-powered rotor that revolved like a carousel on a vertical shaft. Now the Department of Energy is also studying Darrieus machines, mainly at the Sandia Laboratories at Albuquerque, where the largest one erected thus far has a rotor 55 feet wide and yields 40 kilowatts. But many advocates already believe our country would be better off with a great many of these plants producing electrical energy right where it is needed than with colossal turbines feeding current into long transmission lines.

Darrieus generators respond to wind from any direction and are as beautiful as many artists' mobiles. They have to be started like an automobile engine, but they are relatively inexpensive to build.

The Admiral of 10 Million Kilowatts

Behind all this development stands Louis Divone, chief of DOE's Wind Systems Branch, who has been deeply involved in developing wind turbines since 1973. He is a lively, friendly, experienced bureaucrat, distinguished by a beard that reminded a staff writer for *The New Yorker* of Mephistopheles; he presided at the 1979 wind energy systems workshop. Most of our "windmill captains" today report to him as if he were a "windmill admiral."

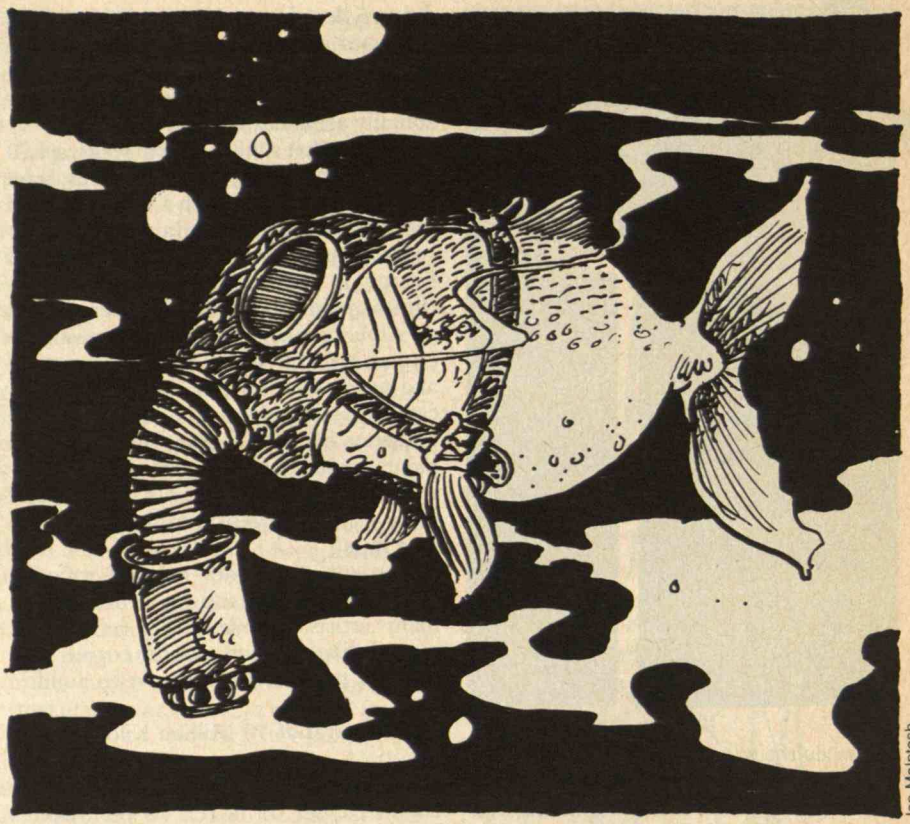
Like most of his staff, Divone believes that durable, simply designed components that can be produced cheaply will be needed to make wind power competitive with other sources of energy that are alternatives to petroleum and coal. But he is an optimist, and he enthuses that by this century's end wind turbines may be producing from 3 to 5 per cent of our country's electrical energy.

Volta Torrey was the tenth editor of Technology Review *(1959-66) before joining the National Aeronautics and Space Administration as a writer/ historian. Now retired, he is the author of* Wind Catchers *(Brattleboro, Vt.: Stephen Greene Press, 1976, $12.95) and a frequent contributor of reviews and comments on technology.* □

A Fish-Eye View of the Polluted Sea

The Forests of the Sea: Life and Death on the Continental Shelf
John L. Culliney
Garden City, N.Y.: Anchor Press/Doubleday, 1979, 433 pp., $5.95 (paper)

Reviewed by Janie Harris



Jon McIntosh

Each rainy night, as Americans dine on prime rib, nibble on asparagus spears, or experiment with new soybean products, tons of pesticides and fertilizers are washed from cultivated fields and trickle down into the marine environment. At the same time, scores of fast-food patrons munch their filet-of-fish sandwiches while fleets of powerful trawlers scrape the continental shelf, dredging up millions of pounds of bottom-fish protein.

With every churn of a seaside industrial plant, thousands of gallons of waste rush into our harbors and estuaries. They leave a diffusing trail of subsea smog which, in some cases, smothers fish eggs and larvae and clogs the gills of adult fish.

The Sea as a Resource

We are served by the sea. We feed from it, mine it, travel on it, and use it as a holding tank for countless forms of twentieth-century garbage. But we are only beginning to realize its limits and understand its vulnerability.

In *Forests of the Sea*, John Culliney narrates the story of the cyclic regeneration of innumerable floating and swimming forms of marine life; he eulogizes the evolution of these organisms and prophesies their doom under our current ocean management strategies.

The science of ocean management is in its infancy. The politics of twentieth-century ocean management serve the marine ecosystem as an impatient stepparent, struggling to cash in the sea's dowry before its value is fully appraised. Culliney predicts that our marine inheritance will be meager at best if we continue on our present course.

The boundaries of marine systems are difficult to define, and trespass is hard to document. State and federal agencies are in conflict over the proprietorship of the sea. Their management efforts involve juggling and appropriating rights to a multiple-use-resource. They encourage a sense of accountability with the use of discharge permits, effluent monitoring, and approved ocean dumping. They employ commerical fish-catch statistics to formulate fishing quotas as we embrace the notion of maximum sustainable yield.

In Culliney's view, these efforts are not enough. The oceans have ceased to absorb our poisons quietly and are coughing up dead fish, tainted crustaceans, and other unmistakable symptoms of an unbalanced system.

Warring factions of developers, fisheries representatives, and preservationists fight a battle for special-interest marine-management priorities. In the Northeast, the Conservation Law Foundation and the Commonwealth of Massachusetts employed their most precise and compelling legalese in an effort to defeat the Department of the Interior before the U.S. Supreme Court. Their mission was to designate George's Bank as a marine sanctuary. Their fight, they contended, would decide which has priority, fish or oil. But marine sanctuary status in this context is unclear — "marine sanctuary" is a management tool with no explicit definition.

Elsewhere, the heroes of Greenpeace stand aboard flimsy rubber rafts strategically positioned between gargantuan whaling vessels and unsuspecting leviathans in an effort to protect the largest mammals on earth.

Counsel for the Defense

Culliney's effort to protect the creatures of the sea involves neither the risks of being run over by a whaling ship nor the presentation of evidence before a court judge. His jury is his readership. One by one he calls the inhabitants of the sea to the witness stand.

In New England the prized female lobster, ready for mating, squirms out of her shell. She crouches, liberated from that chastity chamber but weary from the transformation, vulnerable, hiding from predators and waiting for a male. As her irresistable sex pheromone permeates surrounding the water the male senses it and is drawn to her side. The lobster mating ritual ensues, voyeuristically recounted by the marine biologist. Eventually the resultant lobster larvae hatch and drift away, only to be fouled by unsavory patches of primary sewage, garbage, plastic, and oil emanating from Boston and Lynn.

In the Gulf of Mexico, high concentrations of the pesticides Mirex and DDT have run off into streams and on into the

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sea. The blue crab suffers the effects of that runoff. The crab's symptoms include what Culliney terms "invertebrate hypertension," a dramatic increase in metabolic rate. The chemicals also interfere with the crustacean's primary defense mechanism, the "autotomy reflex," which normally allows a crab to escape simply by detaching itself from a claw seized by a predator.

In the mid-Atlantic, fish larvae and fry, attracted to the warm waters of thermal effluents from power plants, are fatefully entrained on intake screens. Those that escape that untimely demise may then encounter the "black mayonnaise" exuding from illegal sludge dumps in the New York Bight, and smother in a "deep sea smog." The defense rests.

Region by ill-fated region, Culliney exposes the seemingly boundless bounty of the sea's biologic resources as vulnerable, limited, and victimized by man's careless environmental insults.

But *Forests of the Sea* is unlikely to inspire change. Its failing is not a lack of attention to scientific detail, for the author relates the results and methods of scholarly research with care. The problem is that Culliney spins elaborate anthropomorphized exposés of life and death in the marine world in such an extreme fashion that he risks alienating not only his adversaries but also his environmentalist compatriots. Emotional overtones cripple his argument, dilute his persuasiveness, and reduce the overall credibility of the work.

Despite this weakness, *Forests of the Sea* offers an insightful chronicle of the marine biologic community and a reasonable inventory of its environmental problems. In an era when "ocean dumping" is no longer a solution to the waste disposal problem but another twentieth-century habit to be broken, John Culliney offers the fish-eye view of the marine ecosystem.

Janie Harris is a coastal ecologist for Engineering-Science in McLean, Va. and contributing editor on environmental affairs for Gloucester Magazine. □

The Soft Side of the Cancer Problem

The Politics of Cancer (revised and expanded edition)
Samuel S. Epstein, M.D.
Garden City, N.Y.: Anchor Press/Doubleday, 1979, xvii + 628 pp.; $6.95 (paper)

Reviewed by Leonard Reiffel

In all but the most pessimistic there speaks a quiet voice persistently whispering that the world can be made better, that the worst can be avoided, and that the future is worth saving. But what is "better," what is "worse," and what the saved future should actually be are questions with as many answers as there are questioners. And, in turn, our individual answers are shaped and colored by a unique universe of past experiences and perceptions.

In Samuel S. Epstein's universe, there is one bright and burning star marking a path to a more healthy world and a better future. Dr. Epstein wants a total commitment and all-out campaign to stop what he sees as a *man-made* cancer epidemic now engulfing the globe. In over 600 fact-and-anecdote-crammed pages, Dr. Epstein expertly tells the long sad story of our dearly bought understanding that technologies designed to do "good" and yield a profit often do "bad" too and yield disaster.

An experienced and vocal authority on occupational and environmental medicine, the author takes us through a sobering list of tragedies in the workplace, the home, and the environment. While he acknowledges mitigating circumstances in a few cases, by and large Dr. Epstein blames the greed of conniving, profit-minded industry and the ineptitude of bumbling government for the environmental cancer fix we are now in.

Perhaps he is right, but with certain appalling exceptions, well-documented in this book and sometimes in the courts, it could be argued that most of what has happened is a direct consequence of our fragmented and incomplete knowledge of the immense range of causative agents and their interactions.

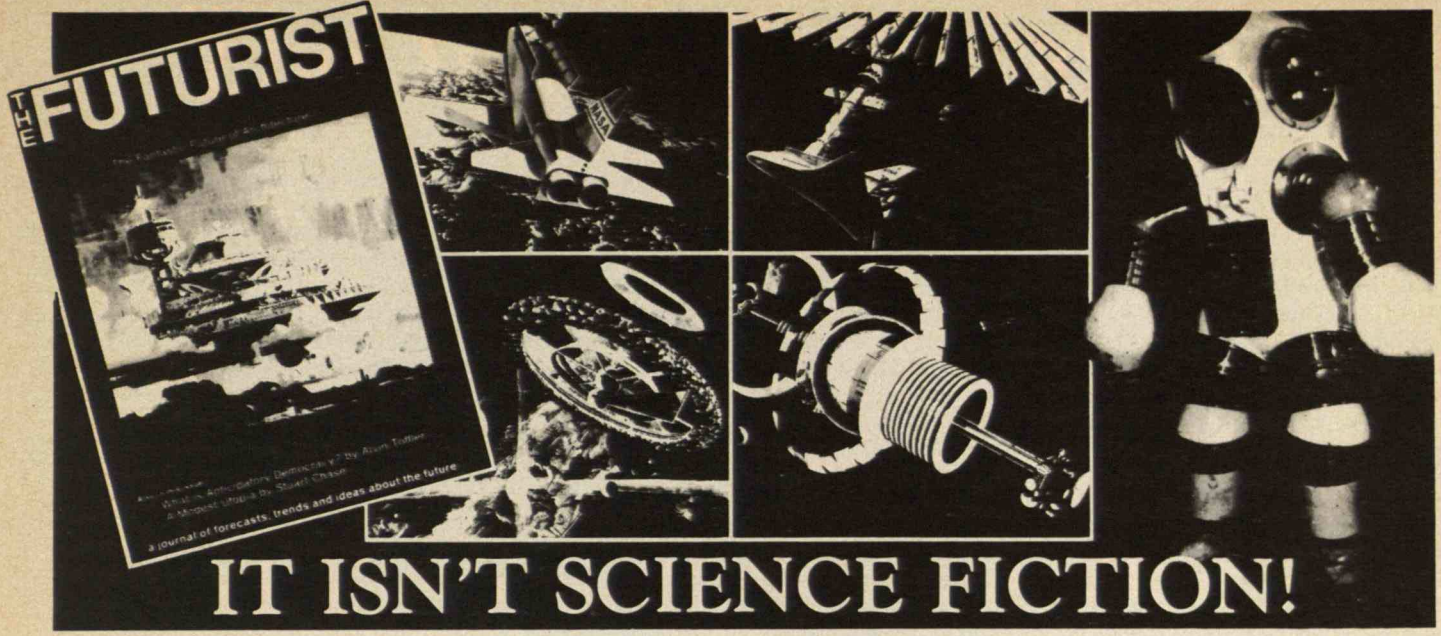
The Soft Path

As in every other area of research and technology, there are fads or timely areas of the "cancer problem" to confront. Dr. Epstein makes a strong case for pressing ahead with action to reduce or eliminate industry as a source of environmental insults that lead to cancer. Few would fault such an objective, and Dr. Epstein does a thorough job of describing the years of effort by many people directed toward this goal, in understandable if not altogether exciting prose. But as useful as the content of Dr. Epstein's message is, what he does not say and questions he does not ask (at least at any length) seem as worthy of note as what he does say. To a considerable extent, he has chosen what, for him, are the "softer" parts of the frontier: of course, let's reduce industrial carcinogens. And of course, let's radically improve our testing, regulatory, record-keeping, and reporting procedures.

But just how far should we go? And how much in both time and money should we be willing to pay? We are not approaching it yet, but where is the point of diminishing returns? In a world brimming with synergistic effects, how useful is the detailed information being collected on individual chemicals? And what should be done about carcinogens that do not come from our factories? For example, what should we do about nature herself as a generator of carcinogens?

Dr. Epstein mentions a few natural materials as problems, but his treatment of these in the overall cancer equation is brief indeed. Aflatoxins, the natural metabolic products of the common mold *Aspergillus flavus* and among the most potent carcinogens known, are treated in only a few scattered paragraphs.

If we were to shield ourselves from the effects of saccharin, red dye #2, and benzene, just to name a few well-publicized carcinogens, would we be victimized nevertheless by the ubiquitous aflatoxins and their relatives? Even as we struggle to drive dangerous industrial contaminants to zero, the Protein Advisory Group of the World Health Organization has proposed tolerating up to 30 micrograms per kilogram of body weight of aflatoxin in human food. One-sixtieth of this amount of aflatoxin B^1 has been shown to produce 50 per cent tumor incidence in rats within 26 months! Nor is *Aspergillus* the sole natural offender. There is sterigmatocystin, considered a universal contaminant of wheat and flour, and dozens or perhaps hundreds of other natural contaminants, many of which remain totally unevaluated with respect to human carcinogenicity, and which are likely to remain ignored for decades. Nowhere in *The Politics of Cancer* is there a discussion of why we



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Global Economic Ills, Lester R. Brown, President, Worldwatch Institute.

Mass Transit and Appropriate Technology, Larry Bell, Professor, Industrial Design, University of Illinois.

An International Decade of Energy Alternatives, Neil P. Ruzic, Scientist-Entrepreneur.

Recycling People: Work-Sharing Through Flexible Life Scheduling, Fred Best, Research Associate, National Commission for Manpower Policy.

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should attend so closely, let us say, to the effect of cotton dust and at the same time ignore the molds in health food stores. What, one wonders, are the politics of such omissions?

In his section entitled "What You Can Do on the Personal Level," Dr. Epstein spends five pages on the subject of foods but *he never mentions any natural hazards to be avoided*. Ironically, among other bits of advice, he eschews sandwich meats, salami, hot dogs, smoked meats, and fish in which the "cosmetic" food additive nitrite is used. "All of these should be avoided, especially bacon," declares Dr. Epstein, and he says they should be replaced by nitrite-free versions. Why does it not concern him that samples of nitrite-free bacon sometimes contain 1,000 to 5,000 parts per billion of aflatoxins, presumably from molds that would not have flourished had nitrite been used to inhibit spoilage?

None of this is meant to cast doubt on the validity and importance of Dr. Epstein's basic message concerning man-made carcinogens. But in my opinion, there is an unstated reason why serious attention is not given to Dr. Epstein's pleas for sweeping action. The public and the politicians, I think, both sense the need for a scale against which all these hazards can be measured, and for a cost/benefit analysis that is not tilted toward the special concerns of one particular group or biased by the availability of readily isolated "soft" targets. Such a global comparability scale, I realize, is not a small order, but no one ever guaranteed that life is fair or that controlling the problem of carcinogenic materials is easy.

Carcinogens as Weapons

Having gently flayed Epstein for focusing too exclusively on only one aspect, albeit a very important one, of the "cancer problem," I cannot close without opening myself to the same criticism by discussing a matter central to my own universe: the ignored potential for deliberate exploitation of our increasing knowledge about the subtle, so-called environmental causes of diseases for criminal purposes and terrorist activities, and even as weapons of undeclared biomedical warfare between opposing social groups.

A year or two ago, a man in Ulm, Germany was convicted of murdering his wife with a carcinogen that the judge would not allow to be named in court but that was dubbed "N." On October 7, 1979, the *Chicago Tribune* carried a story about a man convicted of the "first murder by cancer." Steven Roy Harper apparently used a nitrosamine to kill two members of an Omaha family and to poison three others. Both these incidents involved massive doses, which led to their discovery. But suppose there is a more patient maniac who is willing to wait a few years? To what extent are individuals or, on a statistical basis, larger groups such as minorities or enemy nations vulnerable to general attack at the parts-per-million level, and to what extent is the medical community positioned to detect such quiet assaults should they ever be launched? To me at least, these admittedly ugly questions are already part of the "cancer problem," and unless he was misquoted in a recent interview on the subject, I gather Dr. Epstein would agree.

In *The Politics of Cancer*, Samuel S. Epstein has worked hard and well to bring us a message about controlling important causes of cancer. To devote as much effort as he has to the task is only possible when one possesses true faith that the world can be made better for us all. Dr. Epstein is a believer. His book deserves to be read by all those who want to help.

Leonard Reiffel, Ph.D., is president of INTERAND Corp., a Chicago-based research and development group. He was deputy director for science of NASA's Apollo program and is a consultant to a number of federal agencies. His first novel, The Contaminant, *deals with biomedical warfare and was published recently by Harper and Row.* □

Function and Form: The Chemical Engineer as Architect

The Structure of the Chemical Processing Industries
J. Wei, T. W. F. Russell, and M. W. Swartzlander
New York: McGraw-Hill Book Co., 1979, $22.95

Reviewed by H. Clay Lewis

This book has a much wider significance than its title indicates. Not only is it a landmark among hundreds of excellent chemical engineering texts published since the birth of the discipline in the 1880s, it also has features meriting note by the entire engineering profession.

Why is the book such a landmark? For one thing, it breaks from the common academic overemphasis on the Greco-Roman heritage. Persons trained in the colleges and universities descended from the medieval universities of Europe, steeped in "the glory that was Greece and the grandeur that was Rome," all too often overlook the fact that the university as an institution owes its origin to Arabs. Only under the stimulus of Arabian medical schools in Sicily did Italians organize similar schools on the mainland, and these eventually developed into the medieval universities. Hence, it is refreshing to find that Wei, Russell, and Swartzlander base their work on an Arab model.

However, the major reason the book is a landmark chemical engineering text is its purpose, as stated in the opening sentences of the preface:

The Story of the Caliph

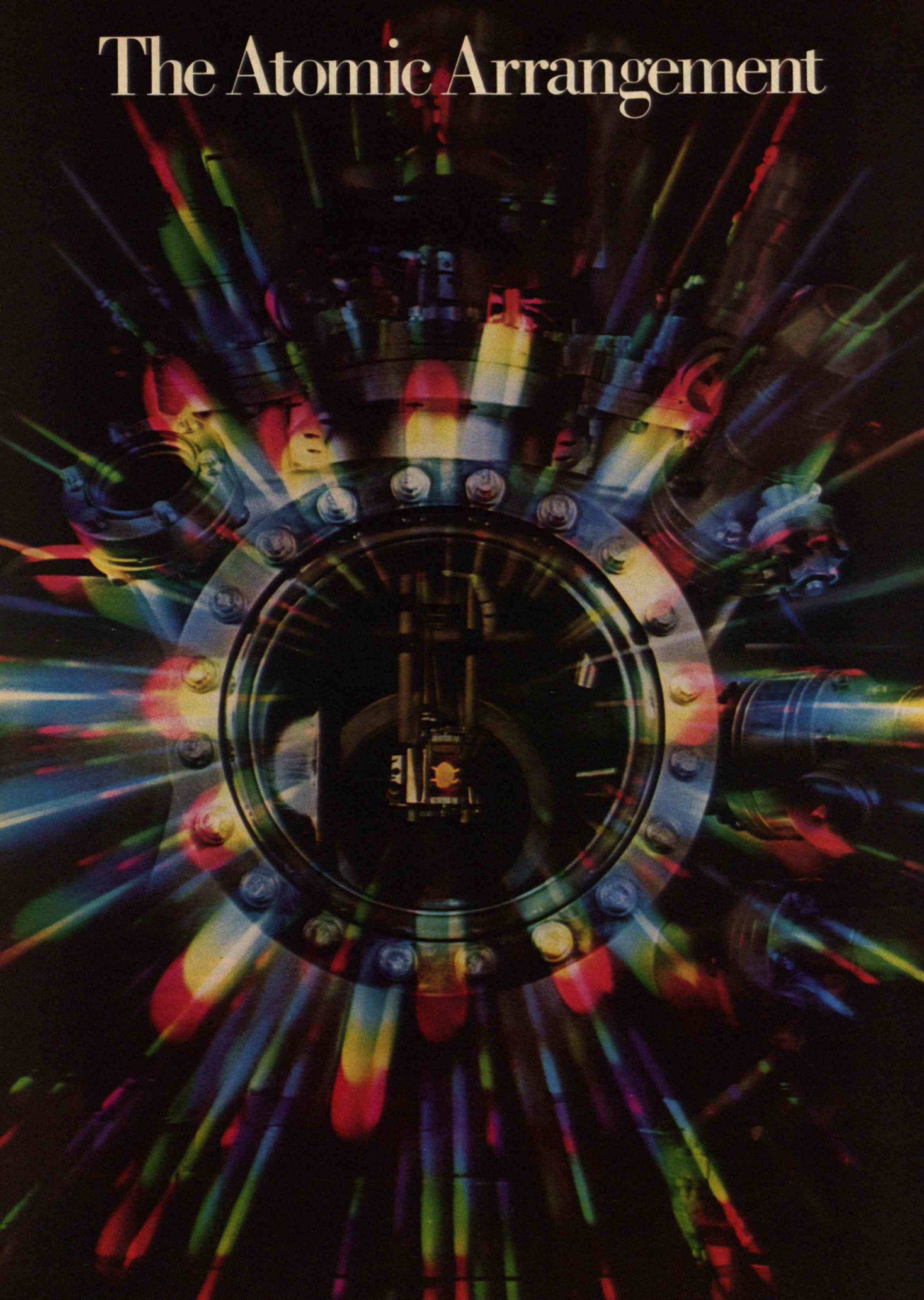
"The Caliph of Baghdad in disguise saw three men working and asked them what they were doing. The first man said, 'I work for the Caliph for a few dinars per day.' The second man said, 'I am an expert rock breaker.' The third man said, 'We are building a road from Baghdad to the seaport.' The Caliph said to his Grand Vizier, 'The first man is a clock watcher, who is only interested in his *pay* in dinars. The second man has pride in his *skill* and is the backbone and sinew of my realm. But the third man understands the goal of the *project*.' The wise old Vizier replied, 'The third man knows what we are doing but not why it should be done. An even wiser worker would have said that the broader *mission* is to improve transportation of goods and people, which improves the quality of life for all our subject people. Our wisest worker would even consider whether flying carpets are better than roads to fulfill the mission. . . .'

"If the Caliph were to return today, he might exclaim that the workers now have wondrous machines and skills but that the progeny of the first worker are more numerous than ever. Even those with pride in their skills often do not fully know the purpose and worth of their work; their lives may be without meaning outside of technical accomplishments, and they may be unaware of their broader contributions."

Previous books and brochures describing chemical engineering as a life work

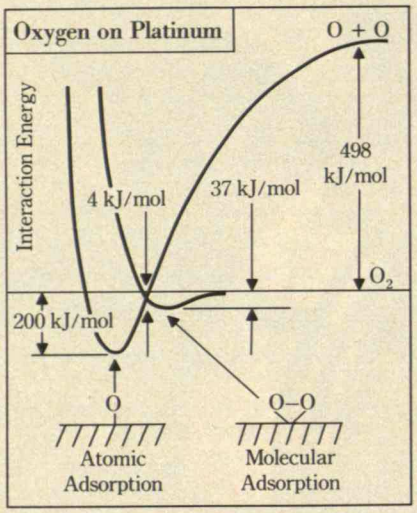
Continued on page 85

The Atomic Arrangement

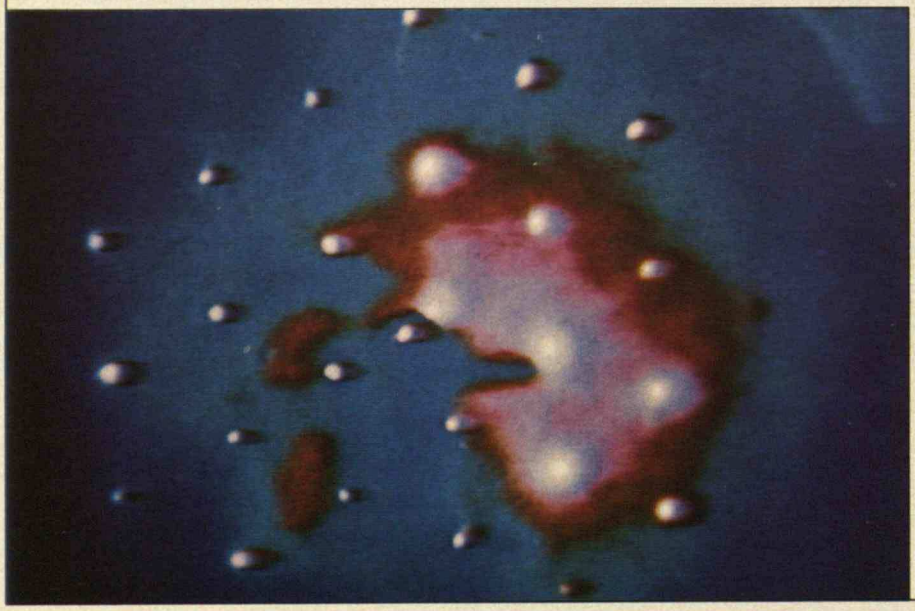


The Atomic Arrangement

In a recent experiment, scientists at the General Motors Research Laboratories studied changes in chemical bonding during the dissociation of oxygen molecules on platinum. Preliminary surface work has explored an interesting new phenomenon: the mechanism of oxygen dissociation over a wide range of temperatures.



A simplified schematic illustrating the reaction potential energy surface for oxygen-adsorption on a close-packed platinum surface.



An electron diffraction pattern which shows diffraction patterns from an oxygen-covered hexagonally close-packed platinum surface at 0° C.

UNDER what conditions will oxygen molecules dissociate into single atoms on a platinum surface? What is the mechanism for oxygen dissociation? Those are the kinds of questions that Dr. John Gland and his colleagues at the General Motors Research Laboratories are investigating to get a better understanding of the chemistry behind catalysis.

Their work has valuable practical implications for the automotive field, where catalysis is used to remove harmful emissions from automobile exhaust. Most cars built in the U.S. use catalytic converters filled with beads containing platinum to chemically transform carbon monoxide and unburned hydrocarbons into harmless CO_2 and water.

While it has long been known that catalysts are an effective way to convert these gases, little is known about precisely why and in what order the basic atomic reactions occur.

In seeking answers to these questions, surface chemists study the elemental composition and geometric arrangement of atoms in the first few atomic layers of the surface and the means by which atoms and molecules from the gas phase bond to the surface.

In his most recent work, Dr. Gland has been studying the adsorption and desorption of oxygen on platinum single-crystal surfaces. This is important because oxygen is the agent that must be adsorbed on the surface to react with carbon monoxide and hydrocarbons to convert them to CO_2.

The experiments were conducted in a stainless steel ultrahigh vacuum system equipped with an electron energy analyzer and a mass spectrometer. The electron energy analyzer allows one to measure the concentration and character of the oxygen adsorbed on the platinum surface. The mass spectrometer is used to measure the desorption of O_2 as the platinum surface is heated. Mathematical analysis of the desorption process allows one to characterize the chemical bond between the oxygen and the platinum surface.

In these experiments, the platinum surface is covered with oxygen at the extremely low temperature of −179°C (almost the temperature of liquid nitrogen) by exposing it to gaseous O_2 molecules. The oxygen remaining in the gas phase is pumped away, and then the desorp-

tion of oxygen from the surface is observed as the platinum crystal is gradually heated to 1000°C.

The oxygen was found to desorb from the surface in two distinctly different temperature regimes—part at −125°C and the rest at about 425°C. By using the oxygen-18 isotope, it was established that the low temperature desorption represents oxygen that was adsorbed on the surface in a molecular form while the higher temperature desorption corresponds to oxygen adsorbed in the atomic form. From an analysis of the desorption process, it was possible to establish the complete energetics. Oxygen molecules from the gas phase strike the surface and are weakly bound (37 kJ/mol). The adsorbed oxygen molecule can either desorb into the gas phase (37 kJ/mol) or dissociate into atoms (33 kJ/mol). The atoms are bonded very strongly (200 kJ/mol) to the surface.

FROM the desorption analysis, it was also possible to deduce the mechanism for the dissociation process. The interesting conclusion that results is that the formation of O atoms on platinum is a two-step process—oxygen is adsorbed in a molecular state and then dissociates to form atoms.

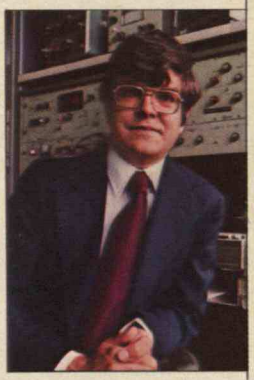
The GM scientists were most interested in learning how this adsorbed molecular species is bonded to the platinum surface. Fortunately, another technique was available to determine the bonding. The technique is called electron energy-loss spectroscopy and is quite new—there are only six or seven such instruments in the world. The measurements not only confirmed the existence of the adsorbed molecular oxygen but showed that it was bound by the transfer of two electrons from the platinum surface into the antibonding π_g orbitals of oxygen. "This was most exciting" said Dr. Gland, "because this is the first time that this type of oxygen bond has been observed on a metal surface.

"We're getting closer and closer to a more specific understanding of catalysis," says Dr. Gland. "The more we learn about simple chemical systems, the better we'll be able to control more complicated systems. That has excellent implications for protecting the environment."

THE MAN BEHIND THE WORK

Dr. John Gland, 32 years old, is a Senior Research Scientist in surface chemistry at the General Motors Research Laboratories. He heads a group of 7 investigators, 4 with Ph.D.s, all involved in work relating to the basic surface chemistry of catalysis.

A graduate of Whittenberg University in Ohio, Dr. Gland received his Ph.D. in physical chemistry at the University of California, Berkeley, in 1973 and joined the General Motors staff that year.



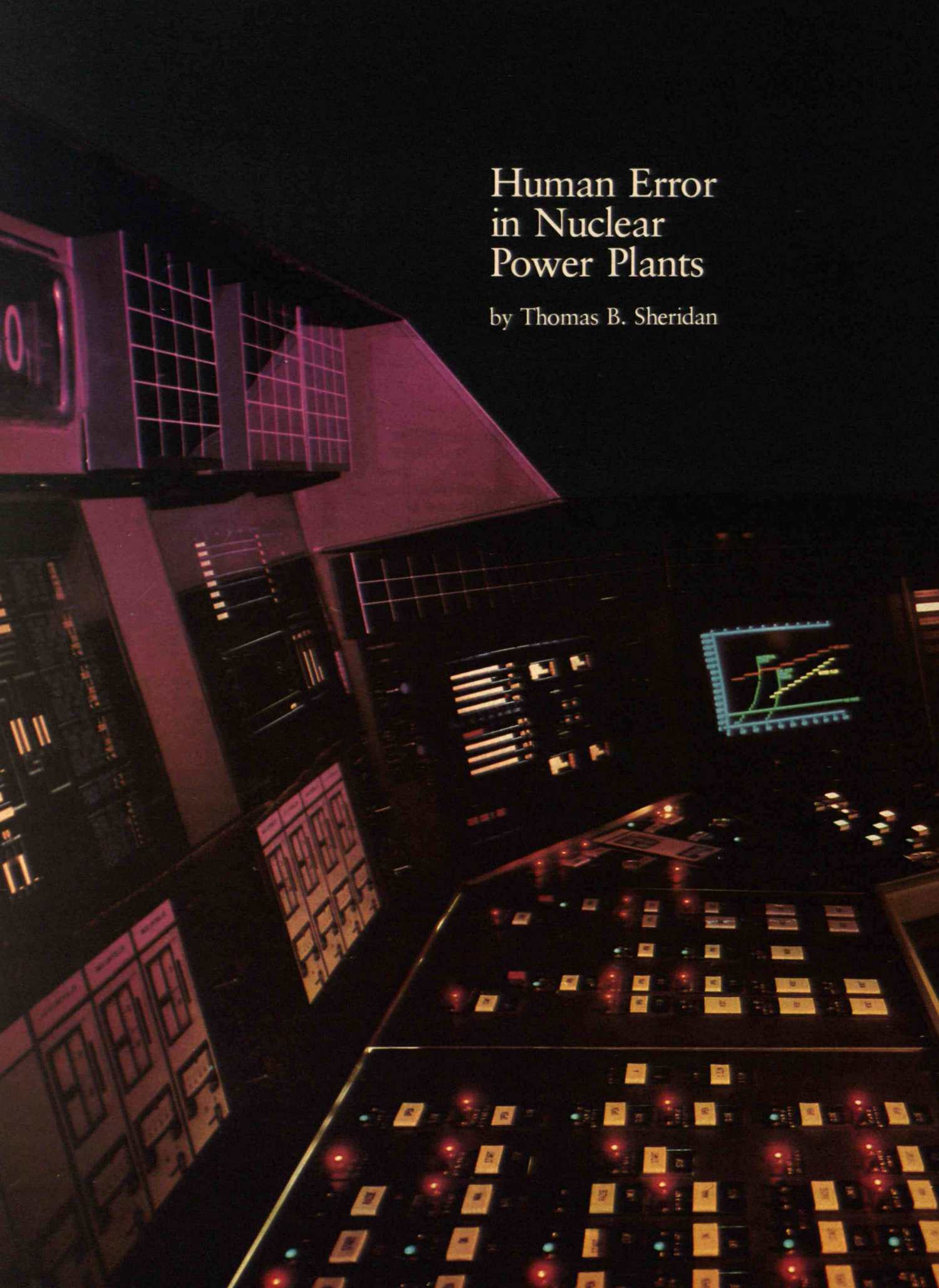
Dr. Gland comments: "I came to GM Labs because I wanted to get in on the ground floor of an exciting new field. The atmosphere here is very open, with lots of cross-pollination among departments. With several hundred people with Ph.D.s here, we've got a lot of human resources to draw on in all the basic sciences.

"Typically, management defines a broad problem, then we're free to tackle the solution in any way we choose. They give us the freedom, equipment and support to get the job done correctly."

In addition to his research, Dr. Gland enjoys backpacking in Wyoming and in the Sierra Nevada Mountains in California.

Human Error in Nuclear Power Plants

by Thomas B. Sheridan

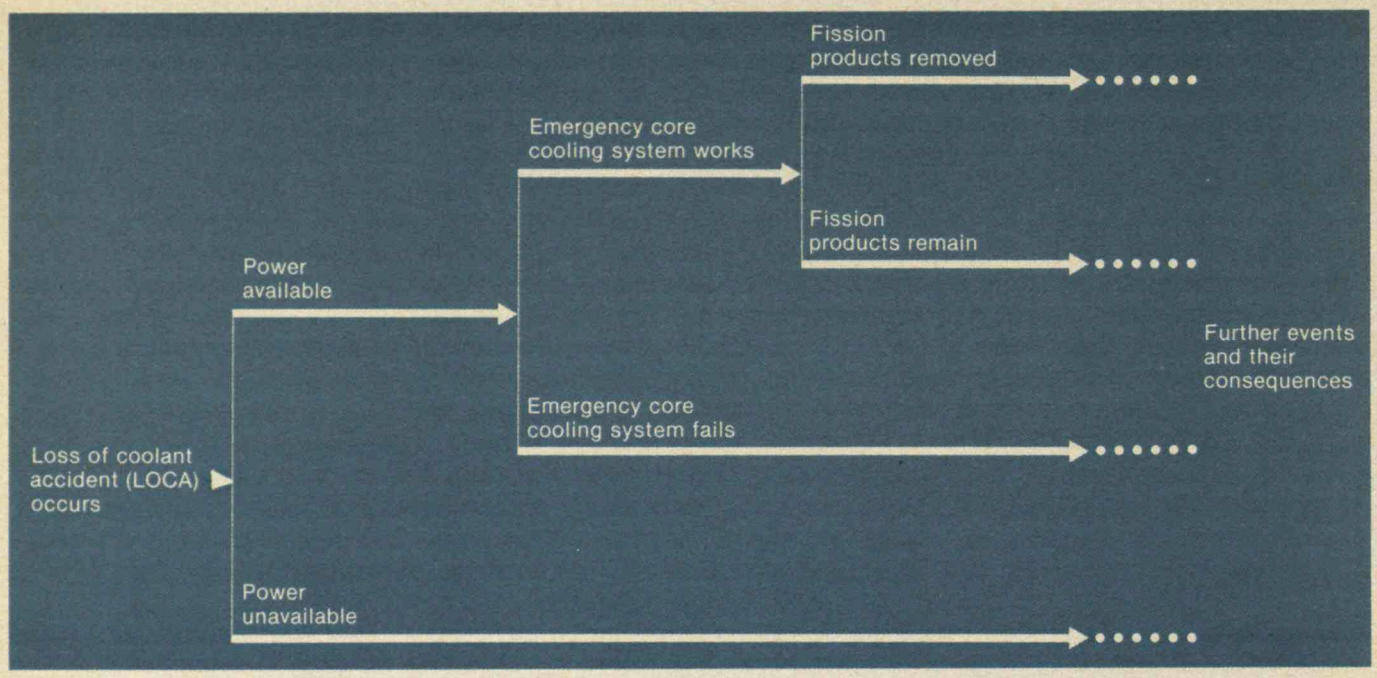


Three Mile Island demonstrated that nuclear power plant operators need more help than their control rooms now provide.

You start driving to the office in the morning aware that you must turn off to run an errand. There is no uncertainty about where you must deviate from the familiar route. Along the way you ponder the day's schedule. Suddenly you find yourself turning into the office parking lot — having forgotten completely to turn off when you passed the appropriate intersection.

Pacific Southern Airlines flight 182 is approaching San Diego. In the cockpit a guest crew member is

A prototype advanced control room in which compact and versatile displays are computer-generated: a harbinger of the new look in nuclear control rooms? *(Photo: General Electric Co.)*

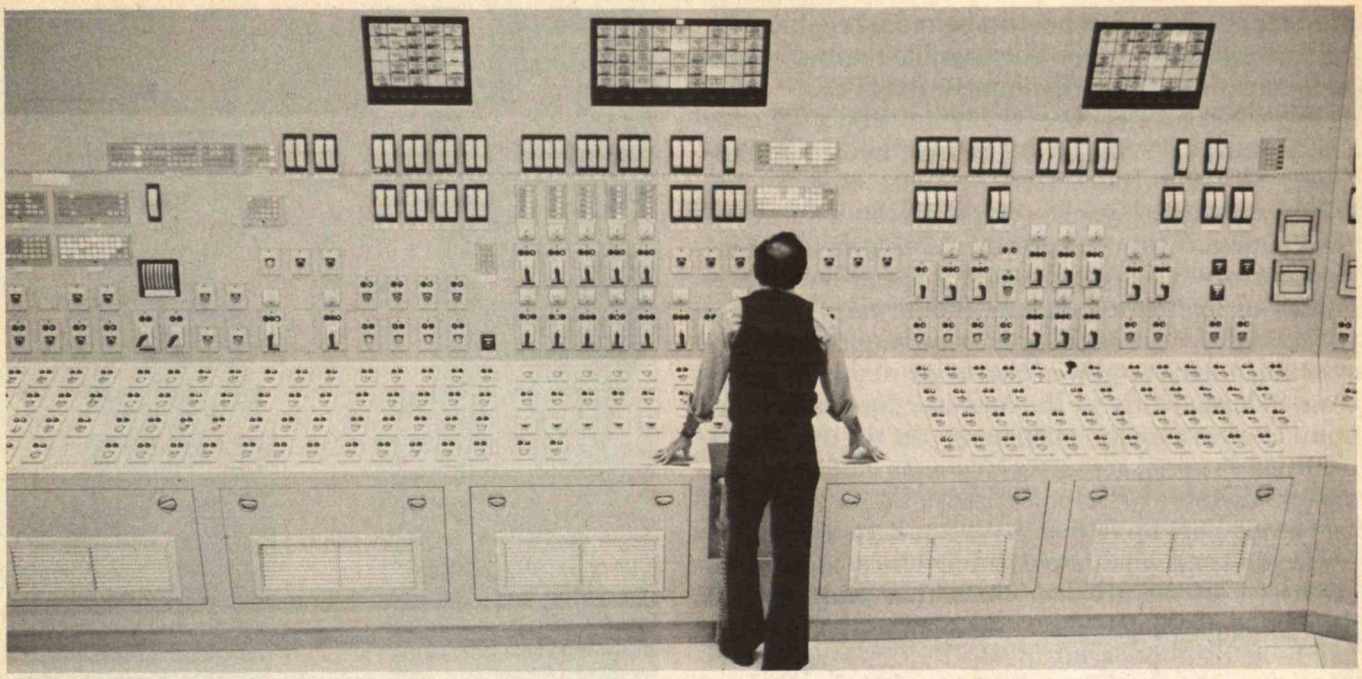


riding in the observer's seat, and the guest, the captain, the first officer, and the flight engineer are engaged in a spirited discussion of retirement benefits. The San Diego controller comes on the radio to give routine landing instructions, adding information about a light aircraft in the area and inquiring whether the pilot can see it. The copilot responds that he thinks he does, but several seconds later he comments that he has lost it. The conversation about retirement benefits continues unabated. The flight recorder captures the pilot's exclamations as a mid-air collision occurs.

It is 4 a.m. on March 28, 1979. In the control room at the Three Mile Island nuclear power plant operators proceed as usual, at the same time aware that in another part of the building auxiliary personnel are working to unclog a steam condensate "polisher" (which purifies the water before it recirculates to the steam generator). A minor leak from the pressurizer has been known to the operators for days and has been allowed to continue. The auxiliary feedwater valves have been shut and for some reason have not been opened. A cardboard maintenance tag attached to the control panel happens to cover the light that indicates the feedwater valve is closed. When a lighted annunciator signals that the turbine generator has "tripped" and automatically shut off (for reasons still not completely clear), the reactor control rods drop into and "scram" the reactor itself, reducing the fission reaction to subcritical

Above: A simple event tree, created by the reliability engineer to help analyze how an initial event might lead to other events. Appropriate probabilities are then assigned to the branches.

Right: An operator contemplates the annunciator lights atop a present-day control board. The photo shows about one-fourth of the total panel space. *(Photo: Joseph Seminara, Lockheed Missiles and Space Co., Inc.)*



level, and the operators verify this appropriate action. The operators monitor the expected transient buildup of pressure that opens the pressurizer relief valve, and later they observe that the relief valve closure light comes on as expected. They do not realize that the indicator is incorrect and that the relief valve has stuck open, releasing significant amounts of water from the pressurized system. While heat and pressure drive the cooling water in the pressurizer out its top, the operators mistakenly assume that the pressurizer has resealed and that auxiliary cooling water is entering the system. They become concerned primarily about the unusually high water level in the pressurizer, and how to shut off what they think is excess water injection that may cause damage. As is now history, they made an incorrect diagnosis. For approximately two hours they do not recognize that rather than too much cooling water, they have too little. Indeed, the particular combinations of temperature and pressure in the reactor mean that it is boiling dry and the fuel rods are on their way to failure.

All three of the situations just described may be called examples of human operator error. The first was trivial; the second and third were not. The context and specific details were different in each situation, and yet the three had similarities. For example, in all three cases the operators were performing a familiar task, which they kept doing as usual in the face of conditions that turned out to be unusual. In all three cases, the operators' attention was diverted at a critical time when new and pertinent information called for responses that deviated from the familiar track. In all three cases there was not a single point when any unique causative human error occurred; rather, a number of problems developed over time.

Not all human errors involve these characteristics. Yet the situations cited are typical of human errors that occur with alarming frequency in complex systems. Reports of accidents such as the dual 747 crash at Tenerife, presumably due to miscommunication between tower and pilots, the Brown's Ferry nuclear plant fire that was due to the improper use of a candle to test for air leaks in the vicinity of combustible insulation, and last year's Three Mile Island accident have made the public increasingly aware that human factors in the operation of such systems must be better understood and accommodated.

But coping with human error poses a fundamental dilemma. Nuclear power, commercial aviation, the manufacture of oil products, chemicals, and hardware, and even office operations of all kinds are becoming more and more automated to circumvent the human operator. Yet no complex system where human lives and/or large amounts of capital are at risk can be allowed to run completely by itself; somewhere there is a human operator to control and monitor and take over in case of emergency. We

presume the overall system to be more reliable with such an operator — but is it possible that we would be better off without that human overseer?

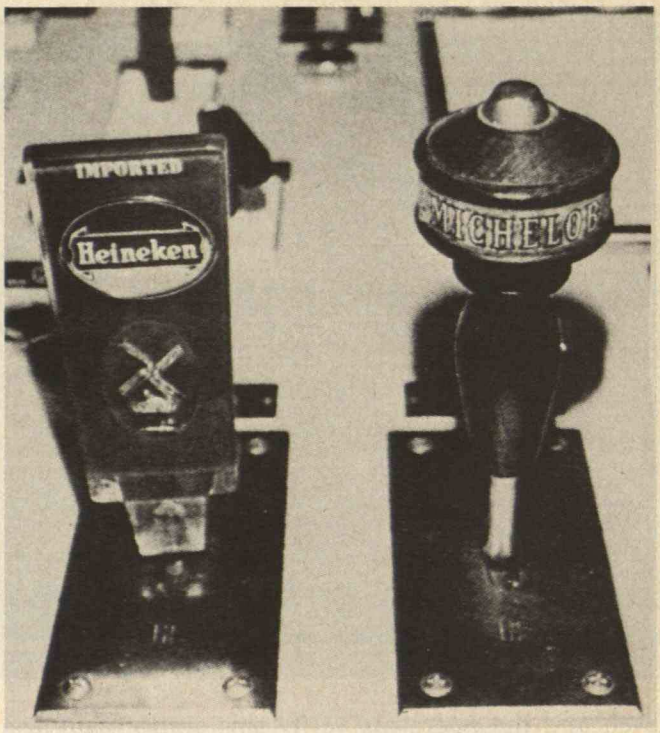
The Nuclear Regulatory Commission's *Reactor Safety Study* (*WASH 1400*), chaired by M.I.T. Professor Norman Rasmussen, assumes that human failure rates are higher — typically by a factor of 100 — than those of major mechanical or electrical components in a nuclear plant, and that under conditions of high stress, human failure rates may approach 100 per cent. That is why automatic safety systems in nuclear power plants are designed to operate independently of the operator for the first ten minutes after a major emergency. Yet the operator is regarded as necessary, especially in an emergency, to make diagnoses of complex and unusual situations that computers up to now have not been able to do. And even after what happened at Three Mile Island (reviewers of the accident claim that things would have gone much better had the operators kept their hands in their pockets), nuclear reactor operators can still intervene in the operation of the automatic safety system. Ultimately we trust people more than machines and expect them to function intelligently in times of crisis.

Human Factors in the Nuclear Plant

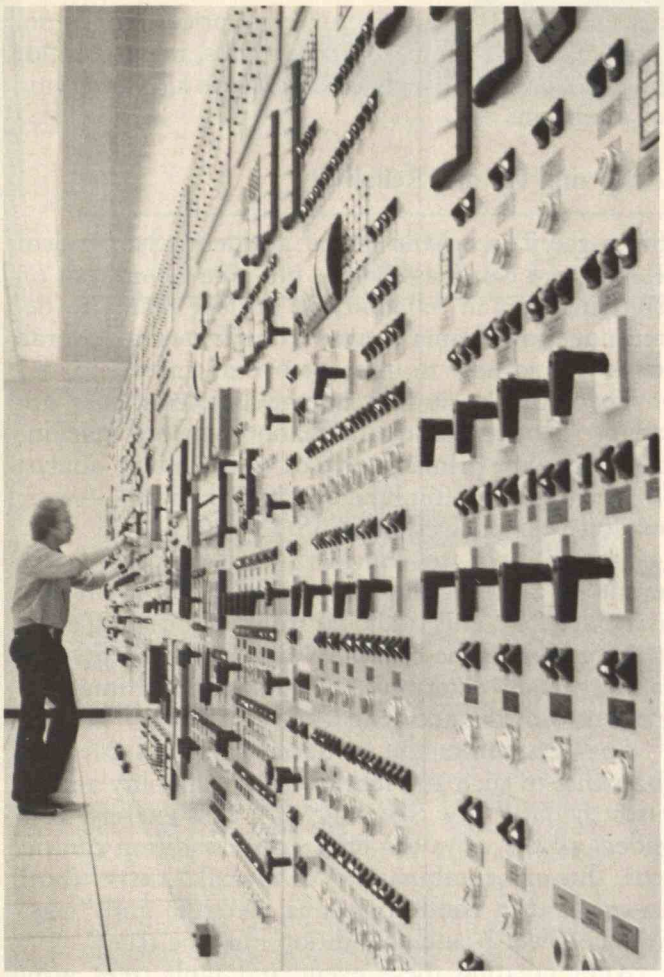
The Nuclear Regulatory Commission requires three licensed operators in or near the control room of a nuclear power plant 24 hours per day. One of these, the shift supervisor, must have passed a higher level of NRC certification than the others. The three are backed up by several unlicensed "auxiliary operators" who typically perform tasks in other parts of the plant while in telephone communication with the control room. At least one licensed operator must be at the controls at all times.

Such operator teams work one of three 8-hour shifts per day. Typically a plant has five such teams, allowing the equivalent of two teams to be unavailable because of illness or training during any week. Usually the shifts rotate 8 hours every week. Some physiologists regard this rotation of schedule to be the worst possible arrangement. The operators' circadian body rhythms barely become adjusted after one change before another occurs. This may be one reason why licensed operators choose to remain at this work for an average of only four or five years.

Many of the licensed operators now in nuclear plant control rooms have transferred from fossil power plants; others received their initial training in



Admiral Hyman Rickover's nuclear submarine programs. An increasing percentage of the operators are men and women who have gone directly from high school into training programs run by the utility companies, where they receive classroom instruction in theory and operation and some practical training in simulators that resemble actual plant control rooms. The operators are taught procedures for normal operations as well as a few "standard accident" cases. However, as noted by the Kemeny Commission report, many of these training programs provide insufficient preparation for coping with unexpected emergencies. Further, in many cases the panel layout of the simulators used in training is different enough from those in the actual plants that operators can become confused. Indeed, some operators find that the actual control panel is a mirror image of the one on which they have just been trained. Various study groups since Three Mile Island have recommended that plant owners install a simulator room identical with the plant's control room for both initial training and refresher training — and that refresher courses be given more frequently than the few days annually typical of the industry. It has even been suggested that teams of operators challenge one another by programming novel hypothetical failures on the simulator for another team to diagnose and "bring under control."



Left: A novel modification of the handles that operate the reactor control rods at one power plant. At first the management in this plant objected to the seeming frivolity, but the operators apparently made a compelling case in behalf of shape coding. *(Photo: Joseph Seminara, Lockheed Missiles and Space Co., Inc.)*

Above: A typical expanse of one of today's control boards — 46 feet wide. Note the bulky control handles, which at one time actually opened and closed large switches and valves just behind the panel, but today only operate tiny electrical relays. Compare this board with the advanced design shown on pages 22 and 23. *(Photo: Joseph Seminara, Lockheed Missiles and Space Co., Inc.)*

Recently, the "human engineering" of the control panels themselves has been called into question. The visitor to a typical nuclear plant control room will find a panel 8 feet high and sometimes 100 feet long covered with long rows of meters and control handles, many of which look the same except for small labels that are barely readable even from 2 feet away. The operators quickly become familiar with the frequently used controls and displays by position, but, as the writer has observed, they sometimes cannot find the less familiar displays or controls for minutes at a time because designers have located these devices on the basis of available panel space rather than for the operator's convenience.

The positioning of controls may be far from optimal. For example, it is not uncommon to find that an operator must adjust a control on one side of the room while another observes the movement of a corresponding display on the other side of the room. Several of the Three Mile Island reports point out that some critical displays in that control room are on the *back side* of panels, while some noncritical displays occupy prime front-panel space. In most plants it is relatively easy to find flagrant violations of the common-sense principles of compatibility between displays and controls and gross lack of conformance with user expectations (*see table on p. 29*). Interestingly, the operators themselves are often so adept at compensating for such design inconsistencies that they perform correctly in spite of them.

In a large ring around the top of the whole control panel are many rows of "annunciators," glass panels several inches square that light up to show a few words indicating various kinds of abnormalities. The casual observer is surprised to find a sprinkling of such annunciators lit during normal full-power operations — a pump down for repairs here, a valve giving trouble there, an electronic instrument being calibrated, and so on. The fact is that nuclear plants tend to have several redundant components for each principal function — and, in turn, backups for these. Thus, the plants are not dependent upon the reliable operation of every single component — provided, of course, that it can be determined which component has failed. Failure of the measuring instruments themselves is ameliorated with three redundant sensors and displays for the most important variables, so the operators can tell when one of the three is inconsistent.

In addition to annunciator lights, there are red and green status lights that indicate when valves,

pumps, and electrical controls are on or off — typically a total of over 3,000. During the first minute of a major loss of coolant accident (LOCA), 500 or more lights may go on or off; during the second minute, over 800. Clearly this is far more than the operators can cope with for minute-by-minute diagnosis during an emergency. Further, the status lights are not usually green for normal and red for abnormal. In most plants green means an electrical switch is open or a mechanical valve is closed, while red means a switch is closed or a valve is open — except that this coding occasionally is reversed. Unhappily, normal-abnormal coding of all controls would require a higher level of computer logic than is now available. The difficulty is with deciding what is normal and what is not. For example, whether certain controls should be on or off depends on whether the plant is at full power, starting up, shut down, or in an emergency mode.

During an emergency, there is little time to identify controls by their labels. Operators claim that they learn "patterns" of control locations and lights and pay no attention to labels. This is probably true for the more frequent and familiar situations, but it is the less frequent ones that are of concern.

A wealth of human factors engineering literature is available, based upon experiments in government and university laboratories as well as field experience in aerospace, industrial, and other applications, to provide detailed design guidance for individual displays, controls, and operating procedures. However, presently there is a real danger that the nuclear industry, under pressure to show that it is responding to the advice of the Kemeny Commission, the NRC's own "TMI-2 Lessons Learned Task Force," and related post-TMI advisory committees, will see the job to be done as a series of detailed "quick fixes." What is needed instead — an *integration* of displays, controls, procedures, and operator constraints within the control room — is more easily called for than achieved.

Concern for human factors and human errors in nuclear plants should not be limited to the control room, though our attention focuses there in this paper. Obviously, human factors and the effectiveness of people determine success or failure at every stage, from the design of a plant and its equipment, through manufacture, construction, installation, and calibration, to testing, maintenance, repair, and management. It is too easy for people working at one of these stages to assume that their predecessors have done a perfect job; therefore, they may not be aware that they are perpetuating a prior error of design, calibration, or procedure. Thus, integration of human factors through these stages is also deserving of attention.

Analyzing Human Reliability

Since the Three Mile Island accident, the Nuclear Regulatory Commission has put a new emphasis on studying human reliability in nuclear plants to determine how human error contributes to overall risks — and how to improve overall safety.

The difficulty is that human behavior does not adapt so neatly to quantification as does machine behavior. The primary tools of the reliability analyst — linear graphs combined with probability — were exploited extensively in *WASH 1400*.

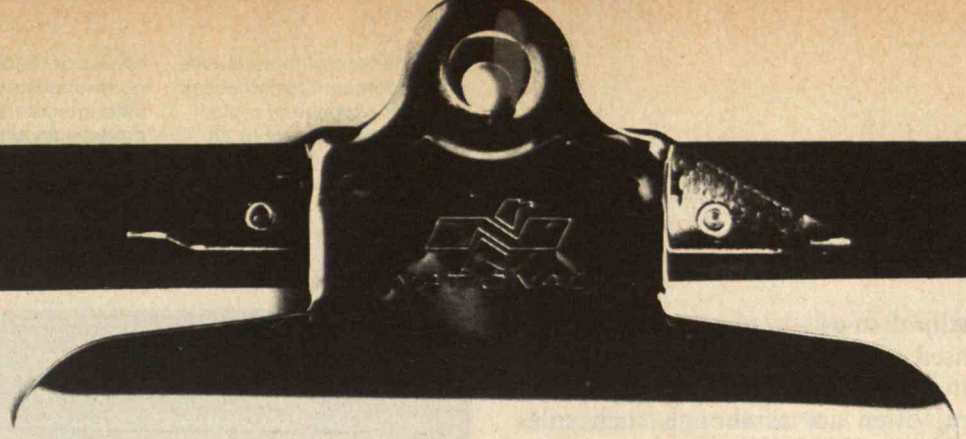
For example, to consider what happens in the event of a LOCA, the analyst draws an *event tree* (*see page 24*). This branches from an initiating event (e.g., a major pipe break) to subsequent events that may critically determine the course and ultimate seriousness of the accident.

To determine the probabilities assigned to branches of such an event tree, the reliability analyst uses the *fault tree* (*see page 31*). This exercise considers all the ways the final (top) condition can occur, through combinations of logical "ANDS" (both lower branch conditions must be true) and "ORS" (either lower branch condition must be true).

After creating these event and fault trees using engineering principles and subjective judgment, failure probabilities are assigned to the branches. This enables the analyst to evaluate the probability of occurrence of the top condition in the fault tree, and this probability is then transferred to one branch of the event tree. Ultimately, through multiplication of the probabilities of casual events, the probabilities of the final branches are established for the event tree.

The reliability analyst would like to carry through this analysis whether the probabilities associated with the fault tree or the event tree are determined by mechanical failure or human error. But estimating conditional error rates for humans poses eight special problems:

☐ It is often particularly difficult to decide what constitutes a human error, that is, how to separate satisfactory from unsatisfactory human performance. Sometimes the literal interpretation of company rules or federal regulations leads to the conclusion that a very minor discrepancy in behavior from some norm — for example, the inversion of



HUMAN FACTORS INSPECTION REPORT

Examples of questionable design observed at a nuclear power plant

1.
A selection switch for boration (adding borated water, which moderates the fission reaction) has four positions: 0 to 550, 500 to 1,050, 1,550, and 2,050. The last two indications really mean "1,000 to 1,050" and "1,500 to 2,050." But that's not what they say.

2.
Two digital borating controllers are side by side and look exactly the same. But the left one is for concentrating and the right one is for diluting. The operator has to remember that the decimal point is one digit before the end on the left controller and after the last digit on the right controller.

3.
Water flows through seven feedwater heaters in succession. Each heater has numbered controls on the panel. The controls are numbered in inverse order to the direction of the water flow.

4.
After heater 3 (above) there are three pumps, A, B, C, and after heater 7 there are two pumps. The switches for these are arranged in two rows: 3A and 3B in one row and 7A, 7B, and 3C in the other row.

5.
Four meters on the left are for neutron flux, and four meters on the right are for the rate of change of neutron flux. The two on the far left correspond to the two on the far right, i.e. they are for intermediate range, and the two which are just left of center go with the two just to the right of center for source range.

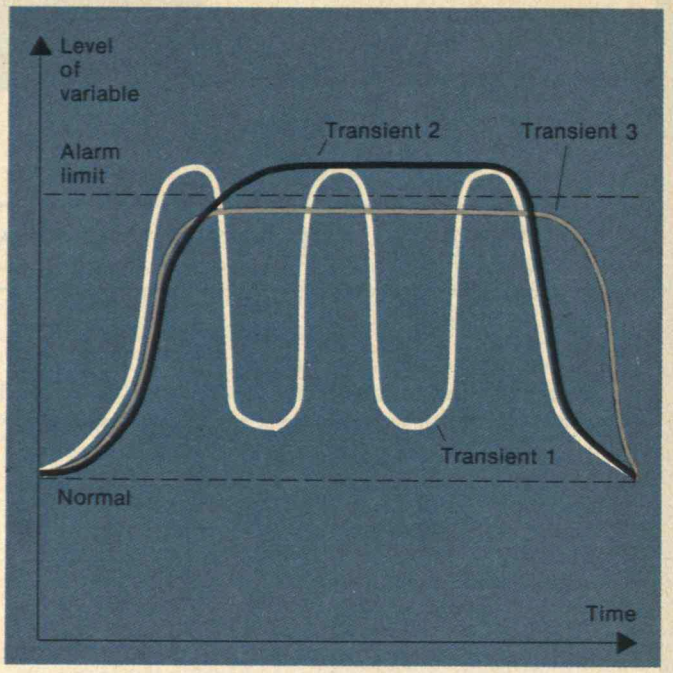
6.
The auxiliary feedwater meters are labeled A (on left) and B (on right). The corresponding switches are also labeled A and B, but B is on the left and A on the right.

7.
There are four steam generators in this plant. There are four pen recorders to indicate temperature in the hot and cold legs of each steam generator. Each pen recorder has two pens, red and green. The first recorder on the left has red for hot 1, green for hot 2. The next one has red for cold 1, green for cold 2. The third recorder from the left has red for hot 3, green for hot 4. The right-hand recorder has red for cold 3, green for cold 4.

8.
General procedures during a loss-of-coolant accident call for the operator to check whether all of the lights are lit in a matrix of check-indicators. But some of the lights (which do not have lettering on them) are not supposed to be lit.

9.
The valves for safety injection of coolant are all nicely arranged in a cluster. The cluster is 60 identical switches arranged 3 high by 20 wide, with only small engraved alphanumeric tags underneath to indicate which valve is which. Mostly the alphanumerics are in order--except for one lost soul which is completely out of order and a long distance away from any other switches it corresponds to functionally.

Photograph: Frank Siteman



A comparison of three curves, which represent hypothetical transient changes of a plant variable with respect to an alarm limit. Transient 1 counts for three errors, Transient 2 for one error, and Transient 3 for no errors. But in practice a different criterion could produce an alternative order in the seriousness of these events.

two minor procedural steps — constitutes an error. Yet operators, based on their training as well as their common-sense understanding of what is required to operate the plant, often act as though such rules have no importance. Sometimes the operator may be required by procedures to "monitor" a certain instrument to see if a "normal" condition exists. Exactly what constitutes "monitoring" and "normal" cannot be spelled out precisely. Sometimes the operator may make an incorrect assumption or formulate an incorrect hypothesis that has a deleterious effect later on, but this type of critical cognitive error cannot be identified or measured on any simple scale. Sometimes, as illustrated in the chart (*right*), an operator may choose to allow some critical plant variable (such as temperature) to slip briefly but repeatedly above a given limit; a second operator may let it go just above that upper limit for a substantial period; a third may keep it *just* below that limit for a longer period. Which is worse? Nominally, the first method involves multiple errors; the second amounts to a single error; and the third, no errors. Yet by some reasonable criteria, the order of seriousness of these errors might be otherwise.

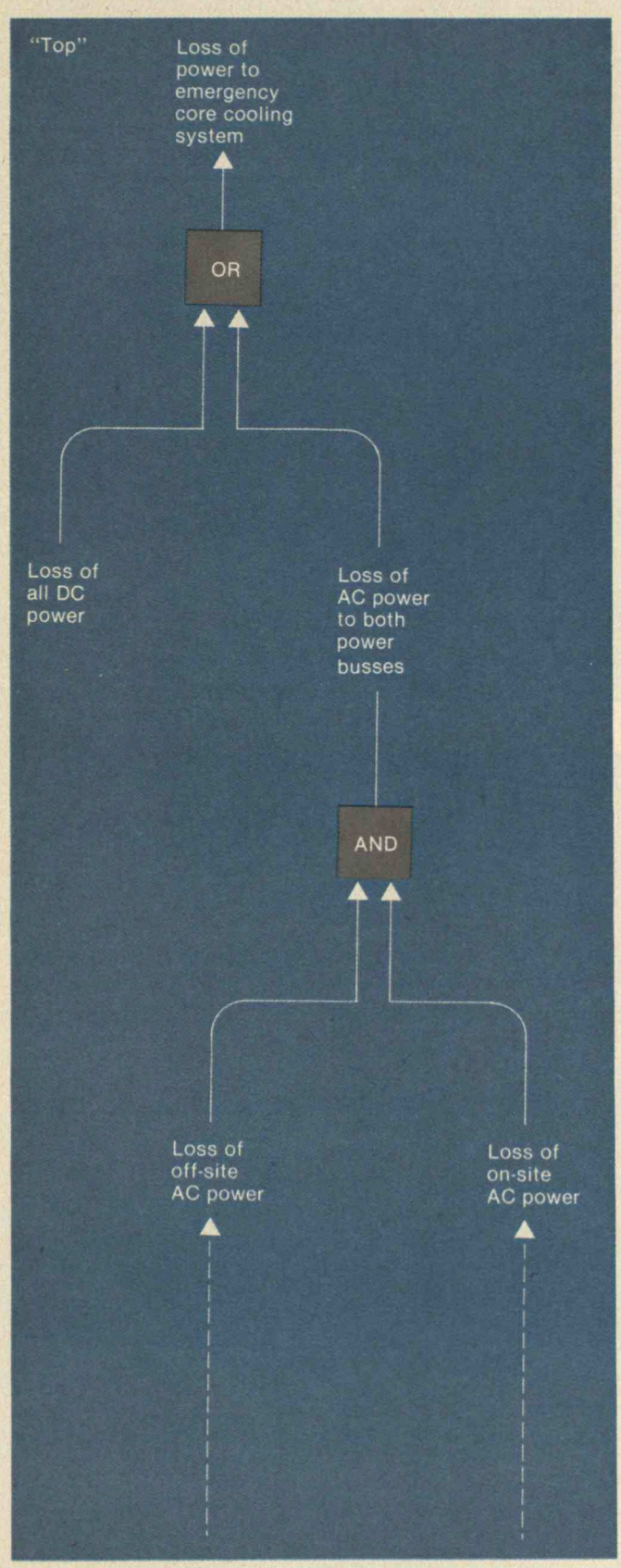
☐ There are ample theories of how machine errors occur, based upon physical laws. But there are no such well-accepted theories of human error. One school of thought contends that the only reason people err is that the physical or social environment does not provide enough feedback signals about the conformance of their behavior to what is expected of them. Translated into the terms of behavioristic psychology, this says that discrimination cues and reinforcers that normally shape their behavior are too few. This view removes the blame from the individual error-maker and places it on the environment. A more popular paradigm asserts that people carry in their heads models of how the environment will respond to their specific actions. Between feedback events from the environment — which may be infrequent — they plan and execute their actions based upon the predictions of their internal models. The basis for error, in this view, is a model that has drifted out of correspondence with reality and therefore gives inaccurate predictions of how the actual environment will respond.

☐ Machine errors are easily classified as to their source — a component device or location within the plant — but there is no accepted classification scheme for human errors. Specialists often classify human errors according to whether they are omissions (not doing the right thing) or commissions (doing the wrong thing), or whether they are more associated with human sensing, information processing, memory, muscle action, and so on. However, such psychological and physiological classification schemes are not practical for most design engineers — which is one reason why these former disciplines have not counted heavily in nuclear plant design and operations in the past.

☐ People don't err unless given the opportunity. Thus, the analyst must determine two independent probabilities: that the opportunity will present itself and that the person will make an error when the opportunity arises. The absolute probability of error is the product of these two.

☐ People are especially prone to "common-mode" errors: operators who make one error are prone to make another. Sometimes this is due to a chain of causality whereby one operator-initiated error sets off an additional error within the plant itself. But often the common-mode error is traceable to linked behavior interactions within an individual. If a waiter accidentally spills food in your lap, he is more likely in his embarrassment to drop his tray on the way back to the kitchen. A driver who commits one error in rush-hour traffic is likely to commit another in recovering from the first. Mathematically this means that such human errors are unlikely to be independent of one another. It means that a person's conditional probability of error is the relative frequency of committing the specified error, given *both*

A simple fault tree. The reliability engineer uses this diagram to analyze the logical contingencies that could lead to various "top events," which then are assigned to a fault tree *(see figure on page 24)*.

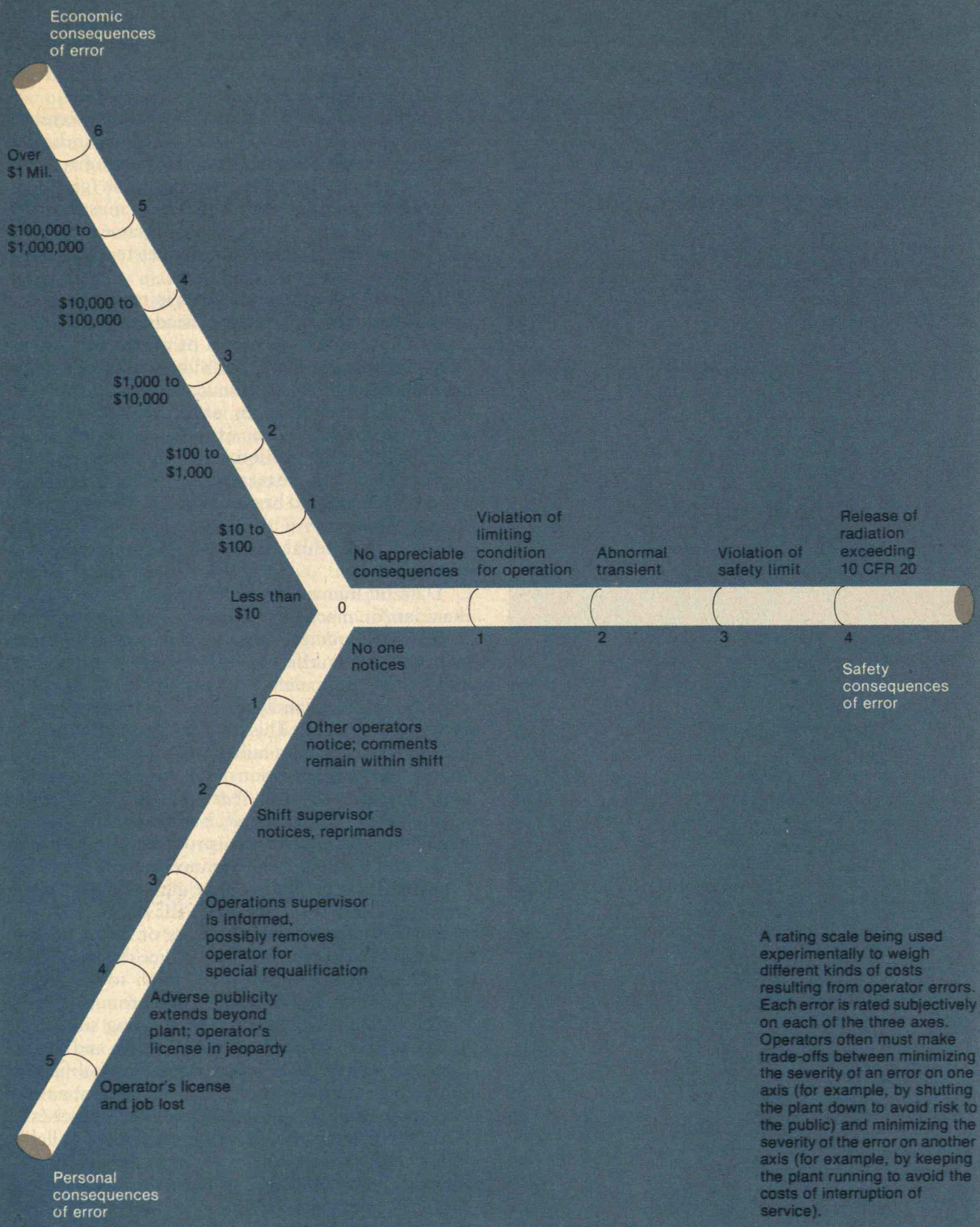


the opportunity to make that error *and* the errors that have just preceded.

☐ People, unlike all but a few machines, tend to discover their own errors and correct them before things get more serious. To obtain a net error, the absolute probability of making an error (given the opportunity and the preceding errors) must be multiplied by the probability that that same error will not be corrected before it has a deleterious consequence.

☐ Nuclear plant operators work in teams, based on the premise that two or more heads are better than one. But there is a great deal of interaction among team members, some of it subtle and unspoken. Such interpersonal communication is little understood but assuredly does affect the reliability of human performance. For example, operators unintentionally could reinforce one another's misimpressions, making the team less reliable than a single operator who would be more likely to think a matter through carefully. This means that human error rates for individuals may differ from those for teams.

☐ Data on human error rates are far less available than data on machine failure rates. Furthermore, the tendency of pumps, valves, and electrical instruments to fail is affected by pressure, temperature, and other easily defined contextual variables, so such data can be validly transferred from one application to another. This is not so clearly true of human data: errors in military situations and industrial production operations may not be valid for nuclear plants, not only because of the different characteristics of the people, but also because of different training, motivation, procedures, and a host of other so-called "performance-shaping" factors. Some human error data may be gleaned from "licensee event reports," which the NRC requires utilities to file whenever abnormal events of certain classes occur. But these reports — like police descriptions of traffic accidents — may leave much to be desired when it comes to accuracy. One promising technique is the instrumentation of training simulators to record errors. Since both new trainees and experienced operators undergoing license requalification routinely perform a variety of normal and abnormal operations during full-scale simulator exercises, a great deal of error-rate data is potentially available. But such data are always subject to the charge that they do not come from the "real thing" and therefore may not reflect the subtle psychological stresses that affect real emergencies. The General Physics



A rating scale being used experimentally to weigh different kinds of costs resulting from operator errors. Each error is rated subjectively on each of the three axes. Operators often must make trade-offs between minimizing the severity of an error on one axis (for example, by shutting the plant down to avoid risk to the public) and minimizing the severity of the error on another axis (for example, by keeping the plant running to avoid the costs of interruption of service).

Corp., under contract to the Electric Power Research Institute, is now developing a technique in which the resulting error data are categorized by many kinds of attributes, including type of plant, type of operation, operator characteristics, and time. The researchers are experimenting with a novel scheme in which various errors are subjectively rated for the severity of their consequences according to a three-attribute scale that includes public risks, economic consequences, and personal/employment implications (*see page 32*).

Human-Computer Interaction in Nuclear Plants

Since the Three Mile Island accident, the nuclear industry (including equipment manufacturers and architect-engineers as well as the utilities themselves) and the NRC are taking steps to insure that human characteristics and errors are factored into the design and operation of nuclear power plants. Some of these needed changes may be brought about by relatively straightforward applications of available human-factors engineering knowledge. But there are two reasons why major improvements related to human factors may take years to implement, assuming nuclear plants continue to be built:

☐ Our understanding of human error, especially in complex systems, in cooperative teams, and under psychological stress, is poor. Human-factors engineers can analyze available experimental data and design experience, but surprisingly few data in the nuclear power context exist. Building the requisite data-base will take time.

☐ The political reality is that it now takes up to a dozen years from the time a plant is designed until it is licensed by the NRC to operate. Control panels and other aspects of the operator-machine interface are part of the basic design, and for administrative reasons are often just as difficult to change along the way as are other parts of the system. Thus, today's new control panel design will not be used for many years.

Given the delay, are there other ways to help the human operator? Clearly, the computer offers promise. Extensive use of computers is being pursued by the industry with respect to both design retrofits and new plants. Computer scientists are learning to make their computers "fault-tolerant" — that is, able to operate effectively despite several failures of hardware. The four American vendors of basic nuclear power plant components (General Electric, Westinghouse, Combustion Engineering, and Babcock and Wilcox) have all developed new control room systems that use computers to provide more information in an orderly format within easier physical reach and more easily understood by operators. Color graphic video displays show diagrams that automatically locate trouble, portray operational trends, make predictions, suggest priorities, and give advice. These new computer systems, if and when they are installed, will aid operators in monitoring plants and diagnosing trouble, and can even monitor the operators themselves. But some operators are reluctant to embrace these new systems; they are fearful of losing the familiar displays and controls where each is in a known location and dedicated to a single function. The new control rooms, though more dramatic and informative than the old ones, will require a new operating style and sophistication.

In this field, as in many others, the development and marketing of computers and computergraphic display technology is well ahead of our understanding of how humans might best use such technology and the new kinds of errors that might occur. This clearly is an area of great promise, but also one of relative ignorance. There is much catching up to do.

Further Reading

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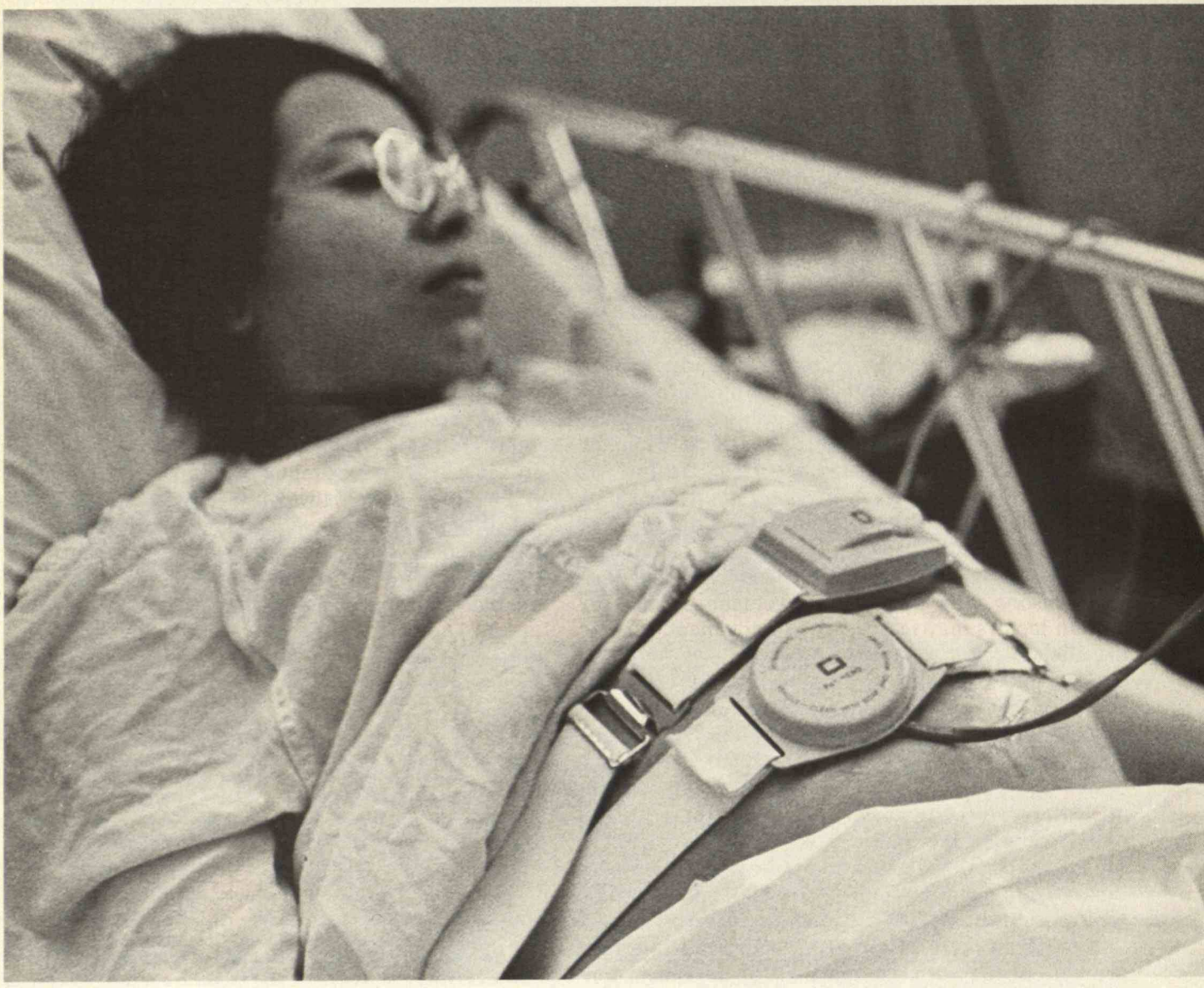
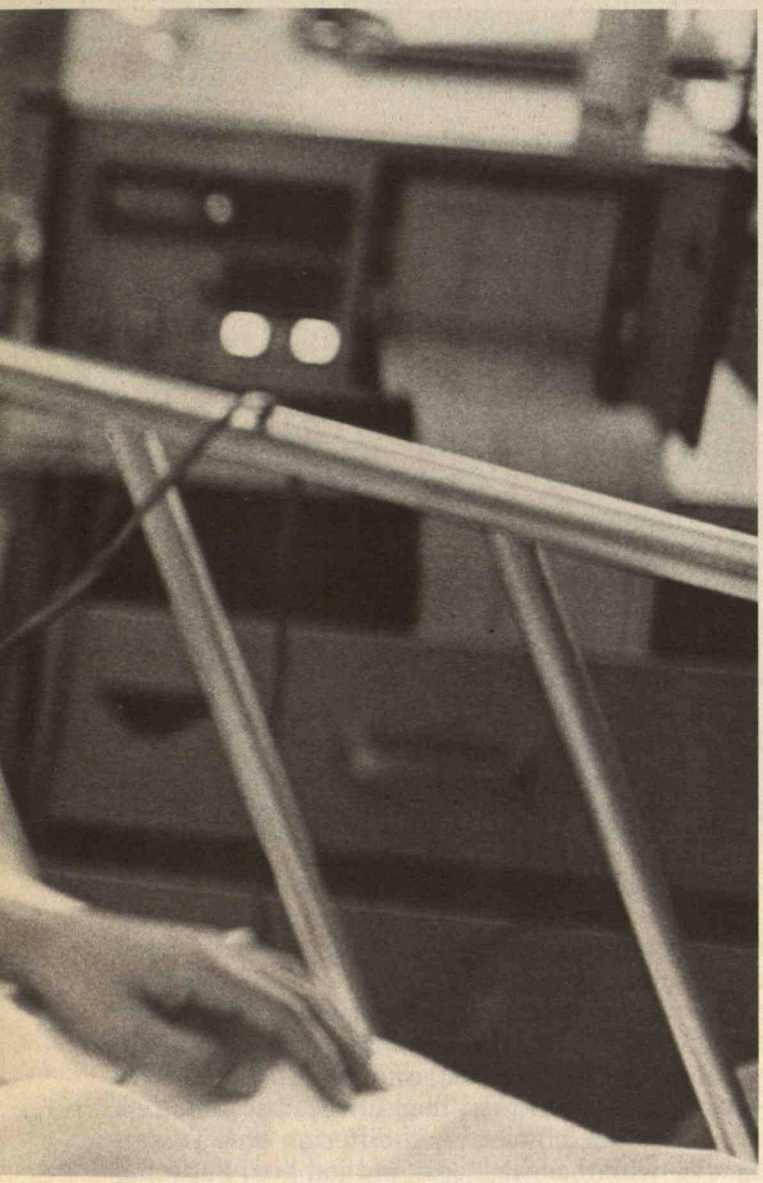
Fetal monitoring systems, shown here with sensors and read-out equipment, continually survey such vital functions as heart rate and respiration. Correlated with their use is a possibly rising rate of Caesarean sections — performed to save the fetus's life when monitoring indicates serious trouble but with increased risk to the mother. The survival of a congenitally defective child, otherwise unlikely with the "screening" effect of a normal delivery, is also more probable.



For several decades, major advances in medicine have been associated with the fruits of medical science — penicillin and the broad-spectrum antibiotics, antiviral vaccines, and chemotherapeutic agents, for example. But more recently, *technology* has come to prominence in perceptions of medical innovation. Nowadays the "machine" in medicine can be too soon and too late with us. Its presence stretches from electronic fetal monitoring before birth to the respirator, intensive care unit, and artificial kidney on the threshold of death. And we may encounter the computerized tomography scanner, the electrocardiogram, automated clinical laboratory analyzers, and many other manifestations of



The Changing Federal Role in Medical Technology

by Richard A. Rettig

A new set of federal institutions is emerging for the "management" of safety, efficacy, and cost in the use of medical technology.

medical technology during our lifetimes.

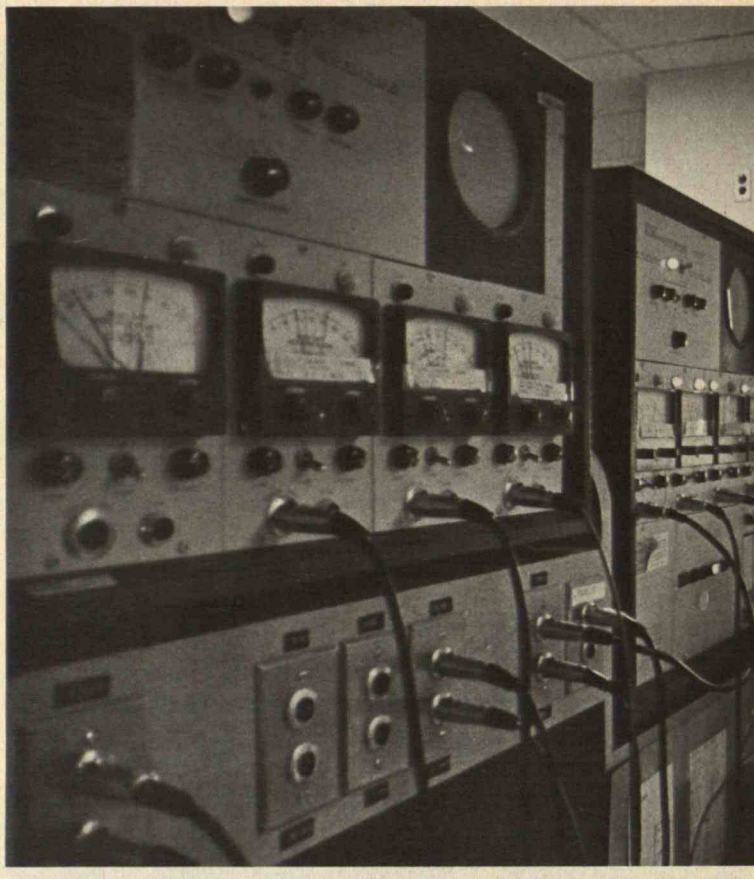
A complex policy debate — involving cost, efficacy, and safety of medical technology — has been occurring during the past few years. And it has resulted in a changing role for the federal government both in policy making and management. The policy shift has been from conscious reliance upon the nongovernmental sector for decision making about the development, diffusion, and use of medical technology to increasing involvement of the federal government. The management transition has been from decentralized to centralized control. Centralization, however, has not meant hierarchical authority. Instead, a fragmented set of statutes and regulations are being administered by a number of federal agencies, only loosely coordinated, with no one really at the top.

Forces for Policy Change: Technology Questioned

Just as there has been rising skepticism about technology in general, so too has medical technology been subjected to increased criticism in recent years. Both the benefits and costs of medical technology have been seriously questioned.

The Karen Ann Quinlan case brought into sharp relief the questionable value of medical technology. Hospitalized after a near-fatal accident and remain-

Heart attacks and coronary bypass surgery are on the rise, and electronic cardiac monitors, shown below, supply continual data on recovering patients. The risks are negligible, but the question is: Do the systems have any impact? Although they have become standard equipment in most medium-sized community hospitals, some observers have challenged their effectiveness.



ing in a coma for many months, she was kept alive by means of a respirator (performing what medical authorities judged her incapable of doing for herself). The parents of Karen Ann watched her steadily lose weight as she remained comatose with no apparent hope of recovery. After consulting clergy and counsel, they sought permission to have the artificial life support withdrawn. The ensuing legal controversy was finally resolved in favor of the parents, and the respirator was eventually turned off. Much to everyone's surprise, Karen Ann Quinlan survived and does to this day — still in a coma.

Whatever the merits of the attending physicians' position on maintaining artificial life support, the Quinlan case riveted public attention on the fact that medical technology could sustain life without reference to its quality. This recognition reinforced a general questioning of the benefits of all life-supporting technology, especially when there is low probability of restoring a patient's life to normal functioning.

The costs of medical technology have also become an object of intense concern. The total Medicare expenditures for end-stage kidney disease, for example, have now reached approximately one billion dollars for about 50,000 patients — an average of $20,000 per patient in 1978. In response, Congress passed legislation in 1978 to introduce cost-control incentives into the program. Another example involves automated chemical laboratory analyzers. These analyze laboratory tests quickly and simultaneously, driving down the unit costs of such tests. But the ever-present threat of medical malpractice suits has led to an increase in the number of tests ordered by physicians.

The introduction of the computerized tomography (C.T.) scanner and its extremely rapid diffusion has more than anything else focused attention on the cost question. The first scanners were introduced into this country in mid-1973. According to a study by the Office of Technology Assessment, 401 scanners were known to be in use by May 1977; and 921 were reported to be operational by the end of 1977. The price of a C.T. scanner in early 1977 ranged from $300,000 to $700,000, and annual operating expenses were between $260,000 and $380,000. But on the basis of 3,000 examinations per year, fees for head scans (including technical and professional expenses), at about $250 per examination, were providing an annual return on investment of 11 to 65 per cent (on a $450,000 machine).

The C.T. scanner also raised questions about efficacy. The head scan rapidly became a routine diagnostic tool, replacing invasive diagnostic techniques while purportedly providing greater accuracy, even before any well-designed studies of efficacy had been conducted. The use of the machine for body scanning is also increasing rapidly, though documentation of efficacy is more difficult, and has proceeded more slowly, than for head scanning.

As illustrated by the rapid diffusion of C.T. scanners — with their high cost, profitability, but somewhat questionable efficacy — the acquisition of new medical technology has not necessarily involved simultaneous consideration of costs and benefits. Consequently, many appalled observers called for externally imposed changes in medicine's incentive structure, and the stage was set for rethinking the laissez-faire posture toward medical technology.

A complex policy response and a new set of institutions for the federal "management" of medical technology have now emerged. This response embraces health planning decisions about hospital capital expenditures, regulation of medical devices for safety and efficacy, and decisions on reimbursement that are sensitive to their effects on technology.

Health Planning

Section 1122 of the Social Security Amendments of 1972 required hospitals to secure approval from the state health planning agency when seeking to make capital expenditures in excess of $100,000. Without such approval, the provision authorized Medicare and Medicaid to withhold reimbursement for services to such institutions. The initial results of this provision have not been encouraging with regard to cost-containment effects, though some analysts have argued that the prospects were limited in the first place.

In 1974, Congress merged the Hill-Burton Program, the Regional Medical Program, and the Comprehensive Health Planning Program into a single health planning effort in the Health Planning and Resources Development Act (P.L. 93-641). One requirement was that states enact Certificate of Need (C.O.N.) legislation by 1980 or lose the federal funds authorized by the act, and a majority of states have now complied. C.O.N. laws require hospitals to seek state approval for major capital expenditures (the threshold of review was raised to $150,000), the addition of beds, and the initiation of any major renovation. The effect of C.O.N. statutes on containing the acquisition of costly new medical technology has been disappointing to many, though expectations may have been unreasonable. But Congress reauthorized the legislation in 1977, and even extended the C.O.N. authority to ambulatory care.

In a parallel development, several state governments have created state health-cost-containment commissions. It is reasonable to expect that this development, together with strengthened health planning authority, will contribute in time to a slower rate of acquisition of new medical technology.

Medical Device Regulations

The Medical Device Amendments of 1976 expanded the regulatory authority of the Food and Drug Administration (F.D.A.). The culmination of several years of consideration by both executive and legislative branches, they arose from a concern over technology-related death and injury to patients and from the absence, theretofore, of adequate federal regulatory authority for dealing with this concern.

Some general controls from the 1938 Food, Drug, and Cosmetic Act were retained — provisions dealing with labeling, adulteration, and misbranding. New regulatory requirements include annual registration of device manufacturers, classification of all medical devices into three classes with different controls for each class, notification of the F.D.A. by manufacturers at least 90 days before marketing of a product, conformance to "good manufacturing practices," and controls over device-related research and development.

Product controls governing introduction of devices to the market are exercised according to the following classification scheme:

☐ Class I — Devices fall into this class if the Amendments' array of regulatory controls is "sufficient to provide reasonable assurance of the safety and effectiveness of the device," or, where information is inadequate for this determination, if the device is not life-sustaining or of "substantial importance in preventing impairment of human health, and . . . does not present a potential unreasonable risk of illness or injury."

☐ Class II — A device not falling in Class I, but for which there is sufficient information to establish a performance standard that assures safety and efficacy, is classified here. It is subject to both the Class I array of controls, and to the requirements

that it conform to the performance standard and that the manufacturing firm be inspected at least once every two years. (Where Class II controls seem appropriate but no performance standard exists, then such a standard must be developed.)

☐ Class III — If there is insufficient information to categorize a device as either Class I or Class II, and a device is life-sustaining or of "substantial importance in preventing impairment of human health" or "presents a potential unreasonable risk of illness or injury," it falls into Class III and is subject to all Class I controls, plus the Class II requirement of regular inspection of manufacturers, plus specific F.D.A. premarketing approval of the device.

The statute provides two routes for obtaining premarketing approval. The first requires the manufacturer to submit an application to F.D.A. containing sufficient information for determining the product's safety and efficacy. The alternate route involves the submission of a "proposed product development protocol" that specifies the tests to be conducted and the anticipated results. If the protocol is approved, and completed test results (later submitted along with all other required information) show that the protocol has been properly fulfilled, F.D.A. approves the device for marketing.

In addition to product controls, the regulatory pattern includes process controls. The "good manufacturing practices" provision of the statute establishes F.D.A.'s regulatory control over the production process. Since this requirement may threaten the small firm, the law requires F.D.A. to provide "technical and other nonfinancial assistance" to help small manufacturers comply with the regulations.

Regulatory authority is also extended to device-related research and development by the "investigational device exemption" (I.D.E.) regulation. Devices being investigated in clinical research, practically by definition, are subject to premarket clearance, since it is the absence of information about safety and efficacy that is the reason for investigating them. It is necessary, therefore, to exempt investigational devices from premarket approval application requirements in order to permit the acquisition of data supporting such an application. The I.D.E. regulation affects not only the manufacturers of devices but also nonprofit institutions such as universities, medical schools, and hospitals engaged in device-related research and development.

Policy research on the effects of the medical device regulations is just now beginning. It is expected that

the regulations will retard the rate of innovation in medical technology, preventing unsafe or ineffective devices from reaching the market, as intended. But the magnitude of the effects on innovation and the nature of the health effects — injuries avoided, efficacious devices kept from the market, etc. — remain to be evaluated.

Analysis of Safety, Effectiveness, and Cost-Effectiveness

In June 1976, the President's Biomedical Research Panel reported to the Senate Health Subcommittee that, among other things, the biomedical research community had no responsibility for transfer of technology from research to clinical practice. The report's reception by Senator Edward Kennedy and Senator Richard Schweiker was chilly, to say the least. The senators strongly believed that the medical research community had a large responsibility indeed for the transfer of technology. But Dr. Donald Fredrickson, director of the National Institutes of Health (N.I.H.), was more sensitive to the changing political winds and signaled acknowledgment of a larger role. Thus, in early 1977, N.I.H. released "The Responsibilities of N.I.H. at the Health

Coronary angiography, a sophisticated system for diagnosing diseases of the heart, is shown below in a pediatric application. Catheterized insertion of dye in the vicinity of the heart permits detailed observation — x-ray "movies," in effect — of cardiac functions. Because of its invasive nature, it is not without risk and should be used selectively. Yet it is becoming increasingly common.

Research/Health Care Interface." This document became the basis of N.I.H. "consensus" efforts involving the identification of medical procedures and technologies, emerging from research, that are approaching clinical application. The intent is to bring together technical and clinical experts and to determine the areas of agreement and disagreement about the efficacy of such procedures. Consensus exercises have been held on hypertension, mammography, dental implants, and other procedures.

The Senate Health Subcommittee pursued its interest in medical technology, helped and reinforced by extensive discussions with staff in the Congressional Office of Technology Assessment and by a draft O.T.A. report on assessing the efficacy and safety of medical technology. In a July 1977 hearing, Kennedy took to task Dr. Julius B. Richmond, the newly appointed assistant secretary for health in the Department of Health, Education, and Welfare (H.E.W.). What was the department doing to evaluate the development and diffusion of new medical technology? he was asked. Richmond's response came in late December 1977, with a report entitled "Health Technology Management at the Department of Health, Education, and Welfare," which outlined six steps in a system for assessing and managing health technology:

☐ Identification and screening of candidate technologies.

☐ Centralized priority-setting of technologies to be scrutinized.

☐ Conducting or monitoring of technical studies.

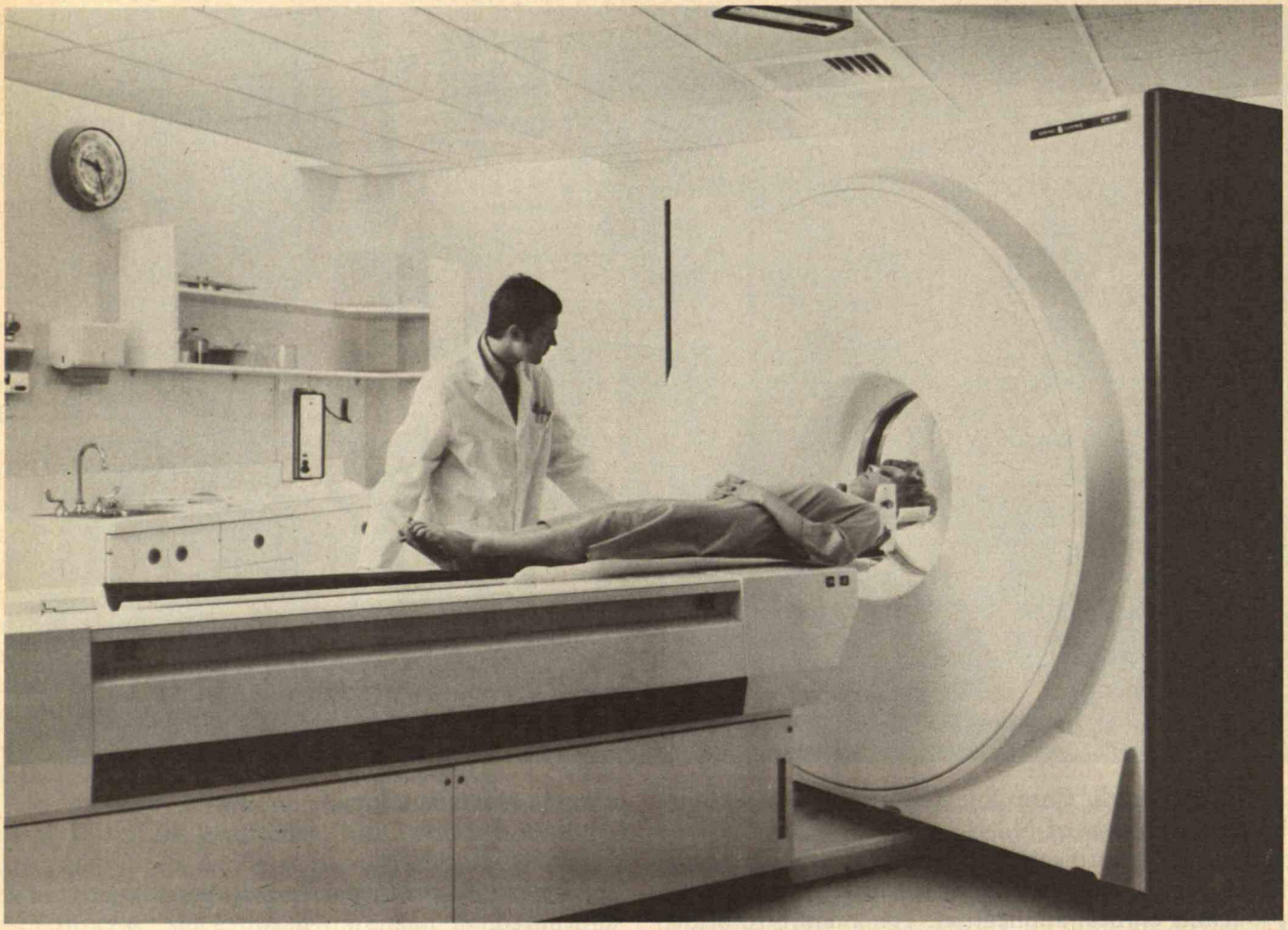
☐ Translation of technical findings for relevant users.

☐ Coordinated decision making to restrain or stimulate the technology.

☐ Intervention mechanisms to implement the decisions.

On the basis of this report and continued interest by the Senate, the department established an Office of Health Technology. In 1978, primarily at Senator Kennedy's initiative, legislation was enacted establishing in H.E.W. a new National Center for Health Care Technology which absorbed the Office of Health Technology. The statutory mandate of the National Center is to assess "the safety, effectiveness, and cost-effectiveness . . . and the social, ethical, and economic impact of health care technologies." The operational meaning of this charter will become clear only with the passage of time. The center has no regulatory function, for example, but all H.E.W. health agencies are

Some critics would describe the C.T. scanner as a marvelous example of a "toy" needlessly applied — one used in many situations where conventional x-ray or other procedures would suffice. Properly applied, however, it is a unique diagnostic tool, although its optimal utilization rate — using the information where it actually makes a difference — suggests consideration of *regional* facilities.



explicitly urged to support it and to take account of the findings of its studies and analyses.

The National Center's research agenda is likely to focus on the evaluation of particular medical technologies; their costs, risks, and benefits; and the development of methodologies for analyzing them. The N.I.H. consensus effort may be absorbed into the activities of the center; in any case, it will be closely coordinated with them. Where the F.D.A.'s concern for efficacy is narrowly construed to mean effective performance of a device under the conditions specified by a manufacturer, the meaning of efficacy used by the National Center is likely to be far broader. Questions on efficacy of one technology relative to competing technologies are likely to be asked, if not answered.

Implications

The shift toward a greater federal role in medical technology derives from the general failure of the medical marketplace to consider both costs and benefits of new medical services. The factors contributing to this situation include extensive third-party reimbursement of medical services which remove the incentive to patients and physicians to economize in the use of medical services, the influence of physicians in affecting patient demand for medical care as well as in controlling its supply, the limited information possessed by health care consumers and a propensity to rely upon physicians' judgments, the incentive to practice defensive medicine to avoid the threat of medical malpractice liability, and the tendency of hospitals to engage in competition for physicians through the acquisition of expensive medical technology.

The shift creates substantially greater reliance upon federal bureaucracies, and herein lies a real dilemma: there is good reason to believe that unregulated market institutions will produce socially un-

desirable outcomes; but there is also good reason to believe that government institutions will be only partially effective in compensating for market deficiencies.

An expanded federal role will bring increased reliance upon formal analysis as an aid to decision making. Cost-effectiveness, risk-benefit, technology assessment — these terms connote efforts to develop some calculus of the social costs and benefits (economic and noneconomic) of new medical technology. Formal analysis, however, has severe limits: intrinsic limits to the formal evaluation of medical technology include ill-defined concepts, unreliable or incomplete data, and the lack of standardized processes for securing expert judgment; resource limits include money, time and analytical competence embodied in people and organizations; and institutional barriers alone will restrict the use of analysis in decision making.

Limited performance from federal agencies can be expected partly because of the nature of contemporary bureaucracy — limited and fragmented authority, inadequate resources of personnel and money, a mismatch between the tenure of political appointees and the time needed to address the problem, and near-impossible requirements of coordination and negotiation among numerous organizational units, to cite but a few problems.

More government decision making will also mean increased utilization of legal and judicial institutions. F.D.A. administration of the Medical Device Amendments is grounded in the requirement of procedural fairness in agency decisions on safety and efficacy, and they will frequently be subject to judicial review as aggrieved parties litigate ambiguous matters of law, regulation, or agency practice. Focusing decision making on choices that are legally defensible, in fact, may preclude broader analytical approaches, and interpretation of congressional intent is likely to be constrained.

Where bureaucratic, analytical, and legal means of conflict resolution are found inadequate, parties at interest will attempt to influence both the rules of the game and policy outcomes by political means. The specific means of influence will include formal and informal efforts to influence the language of legislation or regulation, campaign contributions made to ensure a favorable reception by key legislators, active lobbying for the appointment of executive branch officials favorable to one's views, selective provision of information to public officials or refusal to provide information, and so forth. The general point is simple, but not to be forgotten — politics will pervade all decision making.

We are left then to speculate about the effects of the changing federal role in medical technology. Will the effect of the new policies be to alter the incentives of the medical marketplace, and in the right direction? Or will it simply be to accept the existing incentives and seek to alter outcomes by the addition of new controls? Will there be measurable benefits in improved technology or injuries foregone? Will such benefits be produced at increasing or decreasing cost of technology? In short, will the movement away from the imperfections of the private sector lead to improved health for patients or will it merely reveal the limitations of federal decision making? The answers to these questions will become known only as we move beyond the thresholds we are now crossing.

Suggested Reading

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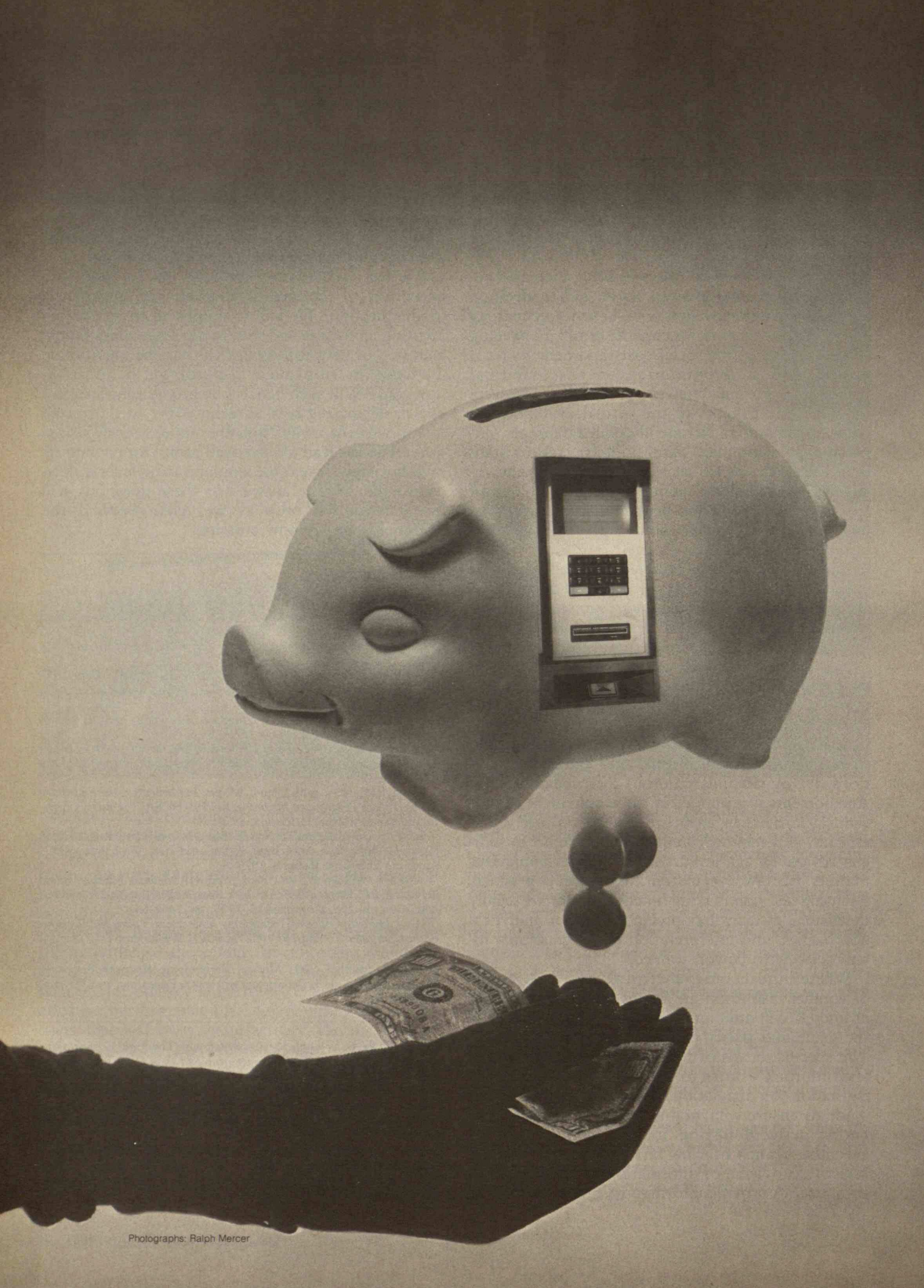
Richard A. Rettig, a senior social scientist with The Rand Corporation, received his Ph.D. in political science from M.I.T. in 1967. His interests include federal research and development policy, federal health policy, and the development and use of medical technology. He has taught at Cornell University and Ohio State University, and is the author of *Cancer Crusade: The Story of the National Cancer Act of 1971* (Princeton University Press, 1977).

This article is based on a paper presented at the Technology and Public Policy Workshop, sponsored by M.I.T. and the Alfred P. Sloan Foundation, Cambridge, Mass., February 16-17, 1979. A longer version will be published in *Policy Sciences* in 1980.



Photographs: Ralph Mercer

The Bottom Line on Checkless Banking

by Dorothy Waldron and Leslie D. Ball

Paperless banking is possible, but customers continue to be uneasy about trusting their money to a machine.

In the last half of the 1960s, the American Bankers Association and the Federal Reserve System advocated a shift from the conventional paper-based payment system to one based on electronics and telecommunications. It was believed that a network of electronic funds transfer (EFT) systems — replacing checks with electronic impulses carried by wire to magnetic tape or disk — would substitute an inflation-hedged, machine-intensive delivery system for one that was labor-intensive and relatively unprotected from inflation.

Yet, as we enter the 1980s, we are still writing checks at a record pace. What happened to the paperless society? In this article we will describe EFT systems, their benefits to both users and financial institutions, as well as the many reasons — economic, social, and legal — why the acceptance of these systems has come much more slowly than expected.

The "Who" and "What" of EFT

Currently, institutions promoting checkless transactions include banks of all varieties, savings and loan associations, credit unions, credit card service organizations, travel and entertainment card companies, and retailers. These organizations all provide funds transfer services and, because of their large commitments, have a substantial stake in the success of the EFT systems. In addition, several large companies, including TRW, National Data Corp., and IBM, have invested substantially in the development of hardware and software necessary to support such large systems.

A banking customer participates in an EFT system by using an automated teller machine (ATM), a point-of-sale terminal (POS), or through the automatic processing of recurring transactions such as paycheck deposits and monthly bill payments. An

"What can be done
to protect our privacy?"
is a primary
public concern.

ATM allows customers to do their banking at a location — for example, a supermarket — more convenient than the bank. A POS terminal allows customers to pay for purchases with automatic bank account debits.

The many services provided by these two types of terminals can be classified into two broad categories — information services and funds transfer services. The four currently available information services are as follows:

☐ *Credit authorization* provides the retailer with proof that a credit card customer has enough credit to cover his or her purchase.

☐ While *check verification* does guarantee there are sufficient funds in the account at that time to cover the check, it cannot guarantee that a check will be honored when presented for payment.

☐ A *check guarantee*, in addition to providing check verification, guarantees payment by the bank whether or not there are sufficient funds in the account when the check is presented for payment.

☐ *File look-up* is a restricted service that allows the operator, usually a bank employee, access to an individual's financial records.

A greater number of services fall into the category of funds transfer:

☐ *Deposit*. A cash or check deposit can be made to checking, savings, or other accounts.

☐ *Cash withdrawal*. Cash can be withdrawn directly from any of several accounts. (One company, American Express, even allows customers to obtain travelers' checks directly from a machine with charges made against their account.)

☐ *Bill payment*. Funds can be transferred directly from the customer's account to an institution owed funds.

☐ *Purchase*. A customer can pay for a purchase by having any of his or her accounts debited and the retailer's account credited.

☐ *Funds transfer*. A customer can transfer funds from one account to another.

☐ *Credit purchase*. To accommodate recurring bills, such as insurance premiums and utility payments, customers can authorize periodic charges against their accounts.

☐ *Cash advance*. This service allows customers to make loans against their accounts.

These varied functions are carried out with a telecommunication link to the central files of the depository institution. The transactions are carried out by "access" or "debit" cards that retrieve data from the bank's central file and manipulate it as directed. Direct payroll deposits and preauthorized payments of recurring bills depend upon the use of automated clearinghouses (ACH). Instructions for such periodic payments are recorded on magnetic tape by the depository institution and given to an ACH, most of which are operated by a Federal Reserve Bank. The ACH, in an operation similar to a check clearing process, then sorts and balances the data from all participating banks and sends back balancing instructions, again on magnetic tape.

The steps in direct deposit of payroll are shown in a flowchart from a recent *Federal Reserve Bulletin* *(see page 46)*. First, the employee gives his employer authorization to automatically deposit his paycheck. This authorization stays in effect until it is canceled.

Each pay period the employer sends a magnetic tape with the information about direct payroll deposits to her bank. If the employee banks at the same place, the transaction is completed immediately. If not, the bank sends a magnetic tape to its ACH. This tape includes information from many employers on many types of payments.

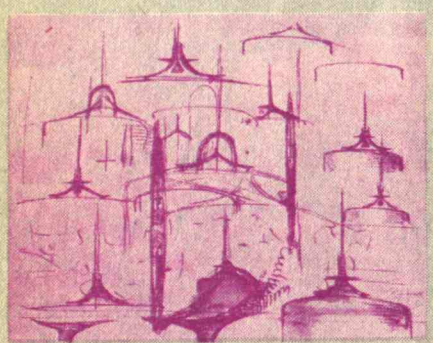
At the ACH, credits and debits are broken down geographically. Local transactions — those made among institutions that are members of the same ACH — account for about 73 per cent of all payments. Transactions among regional ACHs are made through a network.

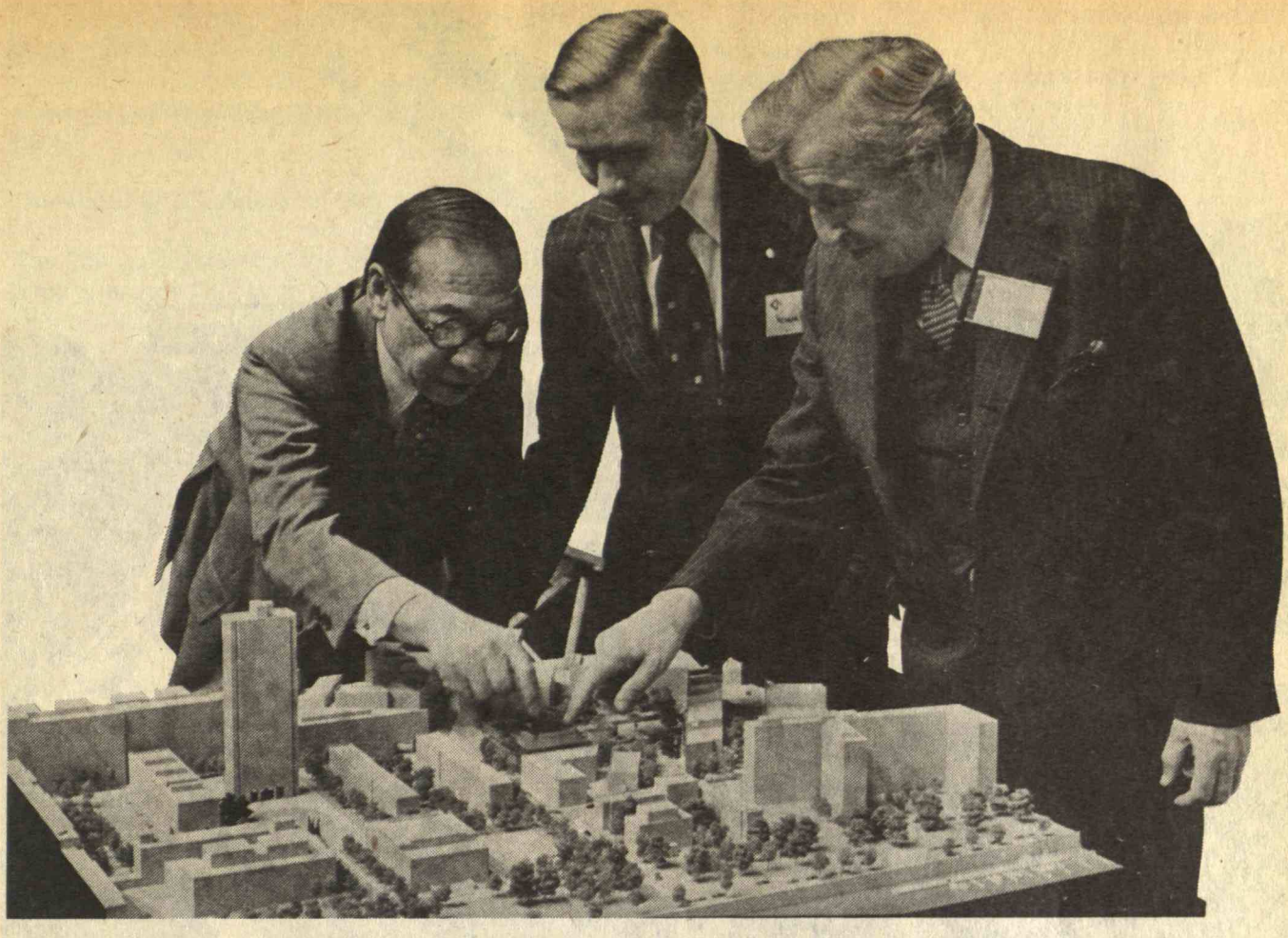
The transaction is completed once the employee's bank is notified. The last step, employee notification, is done by mail.

Direct depositing is one of the simplest transactions. Others, such as the use of an ATM to withdraw cash, involve several checks to verify that the access cardholder is who he says he is and that he has sufficient funds to make the withdrawal. Yet, as these transactions often do not involve other banks, they are considered routine banking procedures.

MIT

This page: part of a photo essay on finals by James J. Snyder, '80, courtesy of *Technique* (see pages A18-A19)





"A Day for Looking into the Future" Arts and Media Technology at M.I.T.

I. M. Pei (left), architect for the new facilities for arts and media technology, points out a model of his design to Vernon Alden (center), Chairman of the Facilities Sponsoring Committee of the M.I.T. Council for the Arts, and President Jerome B. Wiesner, at the eighth annual meeting of the Council. (The building beneath Mr. Pei's elbow is the Green Building.)

Opposite page: the M.I.T. chapel bell tower, and preparatory sketches, by Theodore Rotzak.

Often quoted and much admired, M.I.T. people are frequently stereotyped as brilliant and industrious researchers hovering at the brink of the unknown, manipulating science and technology toward their mind-boggling potential, shaping tomorrow.

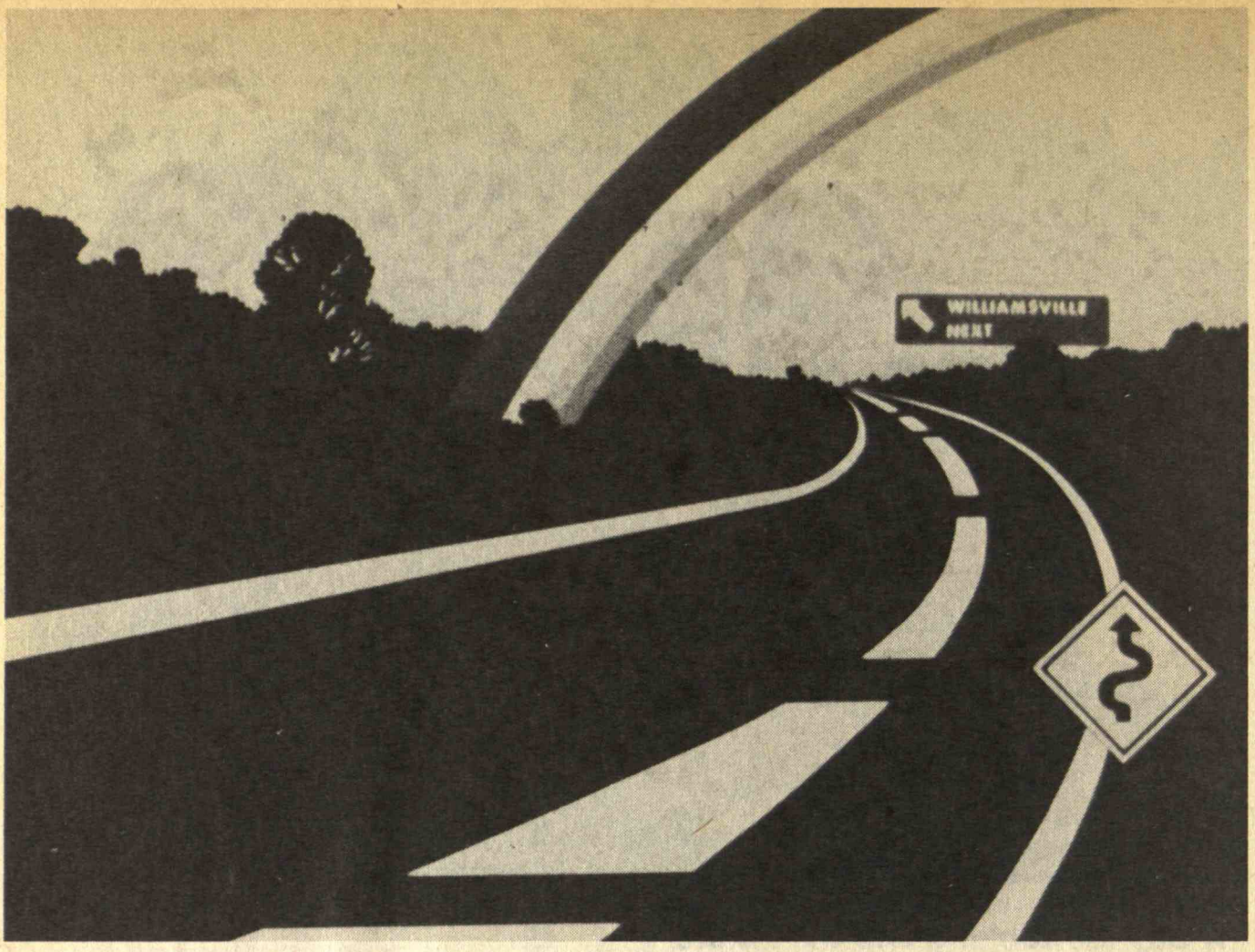
Yes, those people are here. But there is another bustling side to the Institute, usually unsuspected: the arts, nurtured in M.I.T.'s rarefied atmosphere.

Ever since the Hayden Gallery (in the 1950s) and the Center for Advanced Visual Studies (in the 1960s) appeared on the campus, the arts have been gaining ground here. Today's new impetus to teaching, research and practice in the arts appeared eight years ago with the foundation of the M.I.T. Council for the Arts, which since the initiation of its grants program in 1974 has provided $246,500 to the arts on campus and which last fall launched by far its most ambitious undertaking — a $7.5 million center for arts and media technology.

What better environment than M.I.T. to explore the myriad links between art and technology? The creative thinker geared to a visual world can interact with the creator immersed in the scientific universe. They use different tools, but they draw from one imagination. And what better time than now, when recent advances in communications technology are becoming more firmly linked to personal use and expression?

The M.I.T. Council for the Arts held its eighth annual meeting this fall to discuss results — and future goals — of creative inquiry. "Today is a day for looking into the future," President Jerome B. Wiesner told the Council. He quoted from the 1949 Lewis Report: "For the undergraduate particularly, we feel very strongly that the scientific spirit of inquiry and the liberal approach to

"What better environment than M.I.T. to explore the myriad links between art and technology? The creative thinker geared to a visual world can interact with the creator immersed in the scientific universe. They use different tools, but they draw from one imagination."



A work by Alan D'Arcangelo, part of the M.I.T. permanent collection.

life can best be acquired by living within a genuinely creative atmosphere. Intellectual life must provide music, literature, history, philosophy and art for students who are interested in them. Moreover, the work must be conducted on the highest plane."

President Wiesner recalled the Council's first annual meeting in 1972: "Archibald MacLeish called for an integration of the arts, science, and technology in our teachings; and I explored the concept of a dual literacy . . . as the foundation, as our educational goal."

In 1973 the Council began a series of grants in support of the arts at M.I.T. The M.I.T. Symphony's national tour to five cities and its Channel 2 broadcast were the Institute's first national exposure in the arts.

In 1976 the Council joined the Leadership Campaign to help define and move forward the goals for the arts, and sponsored a performance of the M.I.T. Symphony at the John F. Kennedy Center with alumni in Washington, D.C.

Now the Council's work falls into three general categories, explained Roy Lamson, special assistant to the president for the arts: (1) The planning and providing for increased information about the arts for all the Institute's audiences, from prospective freshmen, to students in residence, faculty, alumni and the nation; (2) a coordinated plan for financial activities concerned with programs and facilities in the arts; and (3) a close relationship with arts-related research and technology and with instruction in all the arts.

Two student awards for achievement in the creative arts and in the performing arts were established in the Wiesner name, Luis A. Ferré, '24, Council chairman told the group. Such awards combine Dr. Wiesner's "great interest in the arts with his abiding concern for students and education," he said. Through gifts and pledges, the Council established an endowed fund at M.I.T. which now stands at $28,200.

"The telegraph, telephone, the radio, photography, the stroboscope, TV, all are now part of the communication game. And they force us to understand much more deeply what it is that communication means."

President Wiesner's response to the announcement: ". . . The purpose of all of M.I.T.'s activities in the arts and science and technology is for students, is for education, is for recognition of excellence, for the stimulation of quality performance, something that isn't always as valued today as in the past."

Questions M.I.T. Absorbs Like a Sponge

The Council discussed plans for the new facilities: the central aim is to create a many-pronged but integrated teaching and research program based on recent advances in technology.

"I think it's important to realize that communication in many forms has always been a concern of humans," Walter A. Rosenblith, Provost, told the audience. "The human species has not only these abilities for language; it also has the ability for aesthetic communication. What has been added is the machine, the technologies," he said. . . . "Think of the telegraph, telephone, the radio, photography, the stroboscope, TV — all of these technologies are now part of the communication game. And they force us to understand much more deeply what it is that communication means.

"Gyorgy Kepes, Institute professor emeritus, when he came here in the mid-forties, started asking this question: 'What is it that relates today's technology to today's art? What is it that technology has to contribute to communication? . . . What does it mean to be a source or receiver and what is the medium in between?' It is those kinds of questions that M.I.T. absorbed like a sponge," said Professor Rosenblith.

Under the influence of technology, the whole problem of communication became much more man-made, he said. "Machines have clearly changed the way in which they interacted with human beings and thereby changed our feelings for form, for shape, for sound, for what is meaningful abstraction . . . and suddenly the computer came upon us with an ability to abstract very much differently . . . to store, communicate, symbolize differently, to allow us different cognitive styles for all those that we had before."

William L. Porter, dean of the School of Architecture and Planning, described areas of technology which sparked the development of arts and media technology: the new video/disc, the digitizing of visual and acoustic images and their manipulation in computers, the merging of various media, and the "sophisticating" of the interaction between man and machine.

Computers That Know You: Three-Dimensional Images

Dean Porter showed the Council a videotape of current work at M.I.T. Some excerpts: Nicholas P. Negroponte, associate professor: "What we've tried to do is build computers that could deal with those kinds of graphical vagaries so that the human interface, the stuff which separates people from computers, would be very similar to talking to another human being insofar as the human being can infer what you meant even though you didn't really say it . . . What we've tried to do in the media room is to go to an almost absurd extreme, where the room knows where you're looking, knows who you are, knows where you are, knows what you're saying. It can talk, it can display pictures . . . Just about every channel is available to it and to you in this room," he explained.

Harriet Casdin-Silver, research fellow: "Holography is for me, a sculpture of light. Information is stored within a holographic emulsion that is similar to a photographic emulsion. In the laboratory, a holographic plate of film is exposed to the interference pattern caused by a split laser beam. The plate of film is then re-exposed to a light source and the three-dimensional imagery is reconstructed in space," she explained. She sees holography as a very important communications medium. "Picture a book or magazine and instead of the two-dimensional photographs you see, a three-dimensional image will pop out at you . . . The potential is vast; it is barely touched."

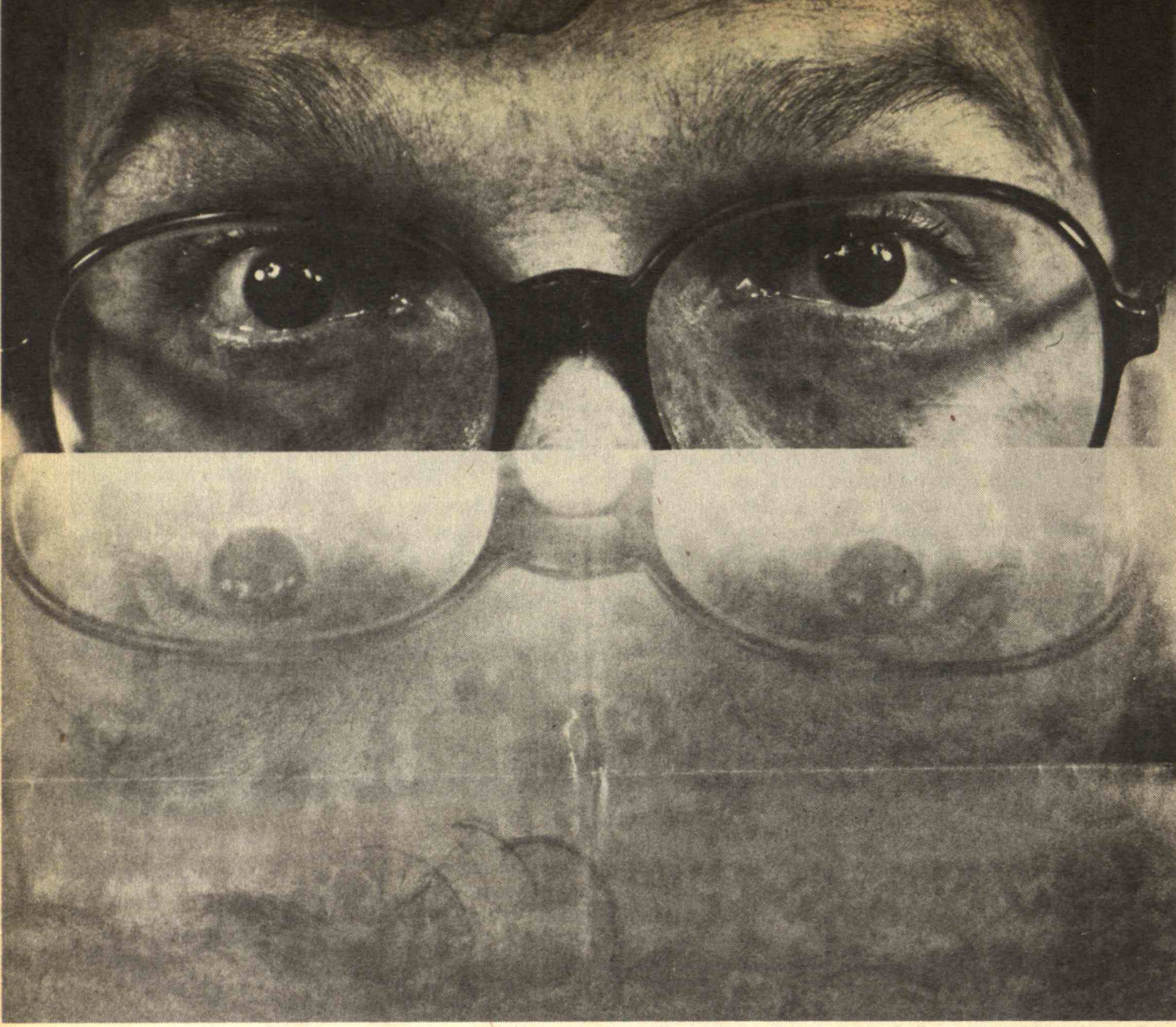
Professor Richard Leacock: "The LP had a very profound influence on

Grants Committee: Preference to Innovative, Imaginative and Interdisciplinary Projects

How do you go about getting a grant from the Council for the Arts? Like anyone else who wants money from a philanthropy, you make a proposal. Meeting three or four times each year, the Council's grants committee receives about ten proposals at each meeting. And since the founding of the Council in 1971, over 100 grants have been awarded, many on a matching principle. "Approximately one-third of our grants budget is awarded on a dollar-for-dollar basis, so in that sense our grants budget goes well beyond the $35,000 allotted for one year. Grants vary in amount from several hundreds to several thousands of dollars and decisions are based primarily upon the quality of the proposal, the qualifications of the applicants to complete the project effectively, and the potential for a broad audience and for student participation," explained Debbie Hoover, Assistant Director of the Council for the Arts. "Preference is usually given to projects that are innovative, imaginative, and interdisciplinary. Our definition of art is broad, as it must be at M.I.T. It includes architecture, design, dance, environmental arts, literature, music, theatre, photography, visual arts and special projects.

"Grants range from individual to large-scale productions involving many M.I.T. organizations. An example of the former is a recent grant which analyzed 3500-year-old glass and ceramic materials and it resulted in a Smithsonian publication and in a chapter of a forthcoming catalogue at the Museum of Fine Arts. An example of the latter might be a full-length videotape production of the *Brandt Spatial Concerto* performed by members of the M.I.T. Symphony Orchestra, completely produced by students and professors in the Film/Video Section. It's being distributed through the Eastern Educational Network," she said.

The grants committee has provided the seed money for projects which are now an integrated part of the M.I.T. curriculum. Some examples: the purchase of medieval and Renaissance instruments, which formed the nucleus of a group that is now the Early Music Society and numbers over forty students; support for the Visible Language Workshop, which began in 1973 and has grown to be an internationally recognized experimental graphics workshop (that is part of the arts and media technology program). A needs assessment study of the arts facilities was also supported by a Council grant. — *M.L.*



Poster photograph from a 1979 Hayden Gallery exhibit, Focusing on Faces. Three artists-in-residence (Joel Janowitz, Jim Dine and Chuck Close) utilized the experimental polaroid 20" × 24" Land camera to create portraits last winter.

Opposite page: Kitty Carlisle Hart, chairman of the New York State Council on the Arts, was guest speaker at the eighth annual meeting luncheon of the Council for the Arts at M.I.T. She is with M.I.T. President Jerome B. Wiesner, and Luis A. Ferre, '24 (right), now President of the Senate of Puerto Rico and chairman of the M.I.T. Council for the Arts.

what people listened to musically . . . I'm convinced that this is going to be true of the videodisc . . . I think that it's going to have a very profound effect on relatively small audiences."

A Unique Building for the Arts and Media Technology

The first phase of the arts and media facilities, planned for construction in 1981, will consist primarily of exhibition and archive spaces for works by contemporary artists and architects. Also included will be teaching and production facilities for film, video and holography, and work spaces for resident artists.

Later phases, which are contingent upon funding, will consist of specialized laboratories, studios, workshops, and teaching spaces. Academic components in graphics, photography, electronic music, and image and audio processing will be accompanied by an Institute-wide educational program of video resources and an experimental multi-purpose theatre.

I. M. Pei '40, of I. M. Pei and Partners, a Council member, explained the design process: We have a site which is a gateway site to the east cam-

pus, and in the midst of a melange of buildings. So our building should not only solve the problem in terms of function, but also it should somehow bring order," he explained. In the next several months we will begin to work very closely with all the program directors who will be housed in the building, and their input will be essential to make it come alive . . . This building and the health sciences and services building will begin to enclose Institute-wide open space which can be used, I hope, for exhibition purposes."

"Like Gilbert and Sullivan"

Luncheon speaker at the meeting was Kitty Carlisle Hart, chairman of the New York State Council on the Arts and a member of the M.I.T. Corporation Visiting Committee on the Arts. "There are those in the academic world who believe that the arts, the sciences and the professions are quite separate entities," she said. "Let me just say that — like Kaufman and Hart, Rodgers and Hammerstein, and Gilbert and Sullivan — science and the arts need each other. George Bernard Shaw once said: 'Next to torture, art persuades the fastest.' The church has always known that. Our colleges and civic bodies are learning it. . . . Technology and the arts are at the very beginning of their union, and the possibilities are staggering."

She summed up the feeling of the group when she quoted Katherine Anne Porter: "The voice of the individual artist may sometimes seem of no more consequence than the whirring of a cricket in the grass. But the arts do live continuously. And they live literally by faith. They outlive governments and creeds and societies — even the civilizations — that produce them. They cannot be destroyed altogether, because they represent the substance of faith — the only creativity. They are what we find again, when the ruins are cleared away." — *M.L.*

Thomas Meloy Professorship in Rhetoric to Help Students "Clarify Values"

"I hope all our students follow the example of Thomas Meloy, '17, a great practitioner, humanist, and innovator," said President Wiesner at the Council for the Arts luncheon, describing the man who established a new chair in Rhetoric at M.I.T. The late Mr. Meloy was the founder and president of Meloy Laboratories, now a division of Revlon.

The Thomas Meloy Foundation has made a commitment of $1 million to fund the chair, President Wiesner announced.

The Meloy Professorship is intended to encourage students to gain a greater mastery in every field of their education.

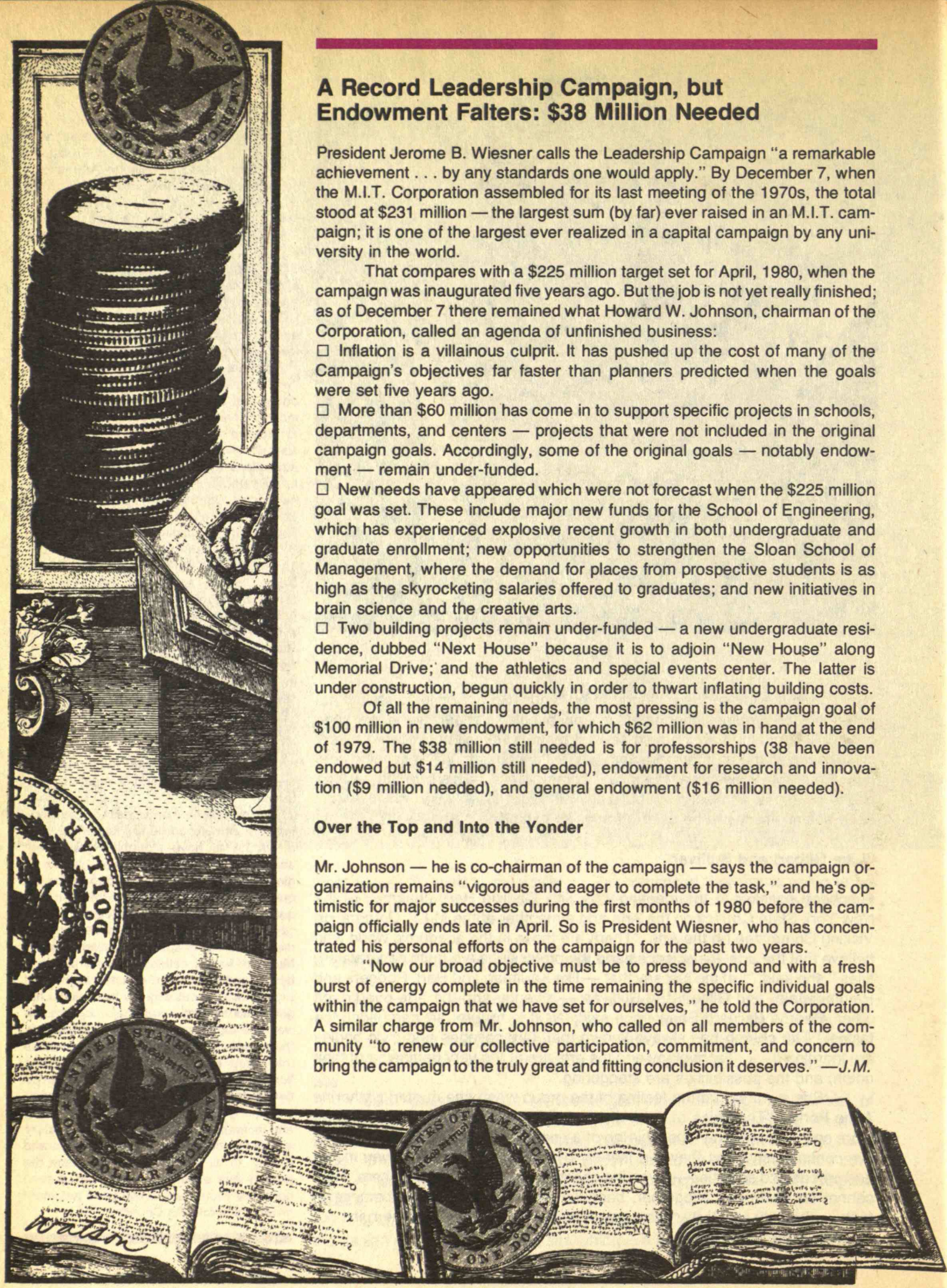
President Wiesner said that Mr. Meloy "was convinced beyond a shadow of a doubt that such a professorship could do more to enrich the lives of our students and to prepare them for future leadership responsibilities than any other field of study or educational experience they could have. He knew from his own experience that it was not good enough to be good at something. One had to be able to tell somebody about it — and do it convincingly."

He announced the first holder of the Thomas Meloy Professorship in Rhetoric: Irene Tayler, Associate Professor of Humanities. Professor Tayler came to M.I.T. in 1976; she is currently the head of the Literature Section of the Department of Humanities. She earned three degrees from Stanford University — a B.A. in philosophy in 1956, an M.A. in American literature in 1961 and a Ph.D. in English literature in 1968.

Professor Tayler told the gathering that "it is by rhetoric, the art of finding the right words, that we clarify our values and set them to work in the world of practical matters."

"Good judgement depends in part on context and formulation; to say something well is already to have thought a great deal about it, as anyone knows who has struggled to find the right words. Good syntax requires clear thinking; good 'rhetoric' requires even more — a knowledge of what is worth thinking, of how it fits and what it means. And this comes of knowing what Matthew Arnold called 'the best that has been thought and said.' It comes of thinking a good deal about why it's best, and what goes into making it well said. By reading well and writing well we root ourselves in those deep human continuities and values that keep one upright, responsive, and flexible as only the deep-rooted can be flexible in times of change," she said.

"I am gratified that M.I.T. is continuing and increasing its commitment to literature and the writing program, to languages and history, to all those studies that trace the primary laws of our nature and help us send down the roots from which good judgment grows," she told the Council. — *M.L.*



A Record Leadership Campaign, but Endowment Falters: $38 Million Needed

President Jerome B. Wiesner calls the Leadership Campaign "a remarkable achievement . . . by any standards one would apply." By December 7, when the M.I.T. Corporation assembled for its last meeting of the 1970s, the total stood at $231 million — the largest sum (by far) ever raised in an M.I.T. campaign; it is one of the largest ever realized in a capital campaign by any university in the world.

That compares with a $225 million target set for April, 1980, when the campaign was inaugurated five years ago. But the job is not yet really finished; as of December 7 there remained what Howard W. Johnson, chairman of the Corporation, called an agenda of unfinished business:

☐ Inflation is a villainous culprit. It has pushed up the cost of many of the Campaign's objectives far faster than planners predicted when the goals were set five years ago.

☐ More than $60 million has come in to support specific projects in schools, departments, and centers — projects that were not included in the original campaign goals. Accordingly, some of the original goals — notably endowment — remain under-funded.

☐ New needs have appeared which were not forecast when the $225 million goal was set. These include major new funds for the School of Engineering, which has experienced explosive recent growth in both undergraduate and graduate enrollment; new opportunities to strengthen the Sloan School of Management, where the demand for places from prospective students is as high as the skyrocketing salaries offered to graduates; and new initiatives in brain science and the creative arts.

☐ Two building projects remain under-funded — a new undergraduate residence, dubbed "Next House" because it is to adjoin "New House" along Memorial Drive; and the athletics and special events center. The latter is under construction, begun quickly in order to thwart inflating building costs.

Of all the remaining needs, the most pressing is the campaign goal of $100 million in new endowment, for which $62 million was in hand at the end of 1979. The $38 million still needed is for professorships (38 have been endowed but $14 million still needed), endowment for research and innovation ($9 million needed), and general endowment ($16 million needed).

Over the Top and Into the Yonder

Mr. Johnson — he is co-chairman of the campaign — says the campaign organization remains "vigorous and eager to complete the task," and he's optimistic for major successes during the first months of 1980 before the campaign officially ends late in April. So is President Wiesner, who has concentrated his personal efforts on the campaign for the past two years.

"Now our broad objective must be to press beyond and with a fresh burst of energy complete in the time remaining the specific individual goals within the campaign that we have set for ourselves," he told the Corporation. A similar charge from Mr. Johnson, who called on all members of the community "to renew our collective participation, commitment, and concern to bring the campaign to the truly great and fitting conclusion it deserves." —*J.M.*

The Price of Oil Doubles, and the Deficit Rises; Paul Gray Seeks a Financial Strategy

When M.I.T.'s budget for 1979-80 was approved by the Corporation last May, the news was not very good — but not very bad: a deficit of about $420,000, a "tolerable, albeit worrisome, level," says Paul E. Gray, '54, chancellor.

The price of oil was then $14.50 per barrel.

Now the Institute is paying nearly $30 per barrel for oil, and the price of electricity has advanced almost apace — though not quite, explains Dr. Gray, because about half the base load in New England is provided by nuclear plants.

The Institute is labor- and energy-intensive, and the cost of its energy for 1979-80 will be more than $10 million instead of the $7 million budgeted. Some of the difference can be passed on to research sponsors, but the net effect on the bottom line for 1979-80 is about $2 million.

There have been few increases — none comparable — on the income side of the ledger, Dr. Gray says, so he now forecasts a $2 million deficit for the current fiscal year — "an unpleasant, very worrisome level," he told the faculty early this winter.

Pressing Down Hard on the Future

No one expects the trend in energy prices to moderate, and its impact can be softened but by no means alleviated by new investments in energy conservation during the next several years (*see right*). So energy costs will present "persistent, grinding difficulties" — a heavy hand on M.I.T. financial planning for at least the first half of the 1980s.

Two other factors will press hard, too, Dr. Gray told the faculty in a financial report late last year:

☐ On average, M.I.T. salaries did not keep up with inflation in the 1970s. Dr. Gray thinks they must do better in the 1980s, to provide "a level of compensation comparable to the quality of our faculty and staff."

☐ Several construction projects remain under-funded — the West Campus athletic and special events center, the new Institute houses ("Next House"), and a new chilled water plant to serve the growing East Campus. To meet some of these costs, M.I.T. will go into the bond market for perhaps as much as $30 million this spring. The net effect of debt service on those obligations will stabilize at about $900,000 a year by 1987, and it will have to be a significant factor in future financial planning.

Dr. Gray admits that "the full strategy for dealing with these problems in the 1980s is not yet clear" to him. But he describes the following as "some elements of the future":

☐ Tuition will have to rise, and for 1980-81 the rate of increase will have to be larger, in percentage terms, than in recent years. Dr. Gray fears that the tuition increase "is going to be a whopper."

☐ Room and board charges will go up, driven — like tuition — by the need to catch up with unexpected 1979-80 inflation as well as cover 1980-81 inflation. Dr. Gray said the changes may be "shockingly large."

☐ New income sources must be found: "The end of the Leadership Campaign cannot mark a lessening of fund-raising efforts."

☐ New cost-cutting will be necessary: "We cannot bring the budget back into balance without renewed efforts at cost control."

Can these things, and others, if necessary, be done? Dr. Gray thinks so. "The essential task," he told the faculty, "is to maintain, throughout this difficult period, our ability to grow and evolve as an intellectual organization, and to serve the needs of the society for knowledge and people appropriate in the times — needs shaped strongly by science and technology." — *J.M.*

A Three-Year $1.5 Million Push to Save 5 Per Cent of Our Energy

By the end of the 1970s M.I.T. was using 35 per cent less energy per square foot of space than at the beginning of the decade. With oil prices now at $30 per barrel, the resulting cost avoidance in the current year 1979-80 is thus about $4.7 million. In the process of this achievement, M.I.T. has become a model for energy conservation among large institutions of all kinds, says Philip A. Stoddard, '40, vice president for operations.

But no one expects the price of energy to stop rising, and the fact that most of the easy fixes have been made and the quick pay-offs achieved doesn't deter William R. Dickson, '56, director of the Department of Physical Plant.

Mr. Dickson and his associates are now embarking on a third-generation energy conservation program — a Building Energy Audit and Modification (BEAM) program.

The plan is to analyze intensively the energy-intensive buildings on the campus, seeking major modifications in their environmental systems that can pay off in energy savings over periods as long as five years. The cost may be as much as $1.5 million, thinks Mr. Dickson; and the goal is campus-wide energy savings of an additional 5 per cent over the next two or three years.

To calculate the pay-off, you need only to know that every time the cost of oil goes up by $1 per barrel, M.I.T.'s annual energy bill (over $10 million in 1979-80) goes up by $153,000.

Community Relations; Not Just Kegs Out the Windows

Houses need to be concerned about neighborhoods and service as well, cautioned Robert A. Sherwood, Associate Dean for Student Affairs. "One thing national fraternity executives are interested in is fraternities becoming a positive contribution to the community, not just a place where noise emanates and kegs roll out the windows," he said. "We're seeing a large turnover in neighbors in the Back Bay area, with conversions to condominiums. And there is pending legislation to prohibit any university from obtaining more housing in that crucial area where 18 of M.I.T.'s fraternities are located.

Some neighbors seemed to have developed an intolerance even for what could be considered "reasonable fraternity behavior," Dean Sherwood says. If a neighbor is concerned, he or she is encouraged to call the fraternity president, a community relations person, or the campus police. Some have called President Jerome B. Wiesner at home, on weekends, insisting that their complaint is an M.I.T. responsibility.

It's easy to ignore one person who constantly complains (and that is a tendency), explained Mr. Sherwood. Unfortunately, that can be a disaster. And we run the risk of losing lodging house renewal licenses.

Fraternity members should get to know neighbors personally, he suggested. One fraternity sent a letter to neighbors about orientation week: why it was done, that it was short-lived, and only once a year. The letter had a very positive reaction.

"The alumni should be asked for advice; they can save you from reinventing the wheel over and over," Dean Sherwood tells the fraternity actives. "Unless these people are taken advantage of, we'll be continually behind the eight-ball in a crisis. So don't wait for a crisis. The community relations problem can be our Achilles heel. We will be forced to contemplate giving up our beautiful off-campus houses — not a pleasant thought. It's a valuable experience to live off campus," he said. — *M.L.*

Fraternities: A New Ally in the Dean's Office

We want the fraternity system to grow, be strong, and be independent, Stephen D. Immerman, business adviser to fraternities and independent living groups, told an Alumni Inter-fraternity Conference (AIFC) meeting last fall. To move toward this goal, Mr. Immerman is now in place in the Dean's office to help with such problems in the fraternities as boilers and burners, roofs, elevators, electrical systems, the Internal Revenue Service, insulation, constitutions, and billing systems, to randomly name a few.

One major threat to the viability of the large majority of M.I.T.'s fraternities with houses in the Back Bay — the sticky issue of neighborhood relations and zoning (see left) — goes well beyond such questions of buying and utilities which dollars can solve. Robert E. Sherwood, associate dean for student affairs, gave those at the AIFC meeting a strong warning: "The community relations problem can be our Achilles heel."

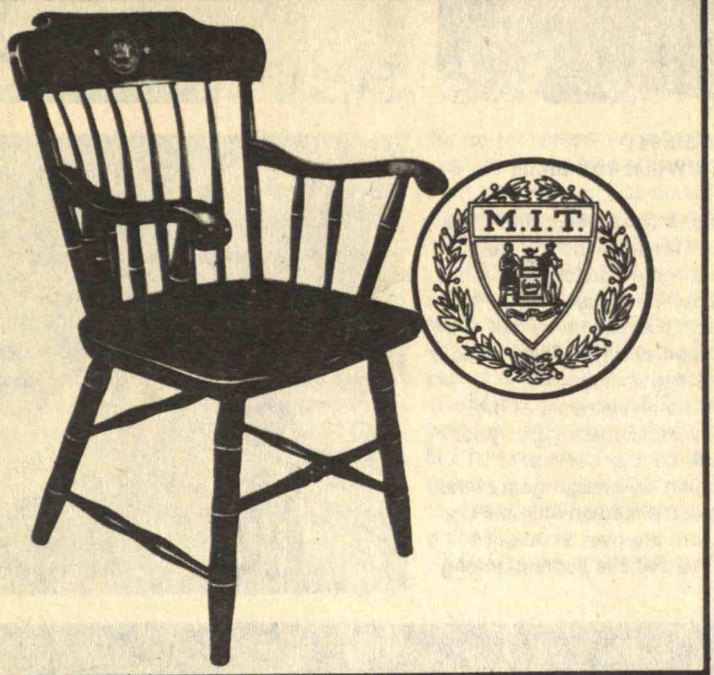
Mr. Immerman is new at M.I.T. this fall — hired "to insure the viability of the fraternity residence system," he explained. "There is the expense side and the income side. The income side is fixed by students' budgets. So we looked hard at the expense side," he said. "There are really two areas where we can achieve immediate and significant impact: energy and food. We are looking into a food co-op which would deal directly with suppliers and negotiate prices."

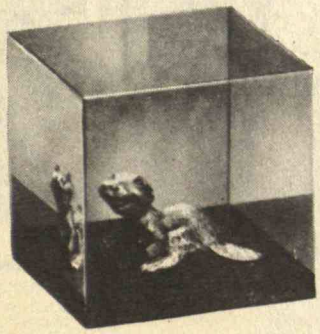
Energy is a larger problem. Independent residences all buy oil from one distributor. "But most of the houses, because of poor insulation, are sieves," Mr. Immerman explained. "The wind blows through the walls." The first step will be to look at where energy is being wasted in each house — "look at burner efficiency, how heat is distributed, recommend products to conserve energy," he said.

An ambitious project: an across-the-board inventory and analysis of the physical plant of every individual fraternity residence. The goal would be to develop a plan for each house so it wouldn't *react* to problems but anticipate them, replacing individual systems before they give out completely and create expensive emergencies, he explained. If problems can be anticipated, the frantic last-minute crises management technique will be avoided. "We can't expect M.I.T.'s Physical Plant Department to do an inventory of the structural and electrical systems in each house, so we're proposing that a consulting firm do the analyses, in a form that can be immediately computerized so we can see the results," he said. Each inventory would indicate what kind of shape the house is in, what the life span of the systems are (how long until the roof goes), and cost projections. — *M.L.*

M.I.T. INSIGNIA

A GOOD WAY TO REMEMBER





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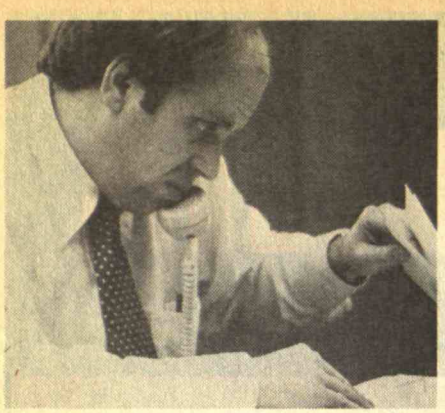
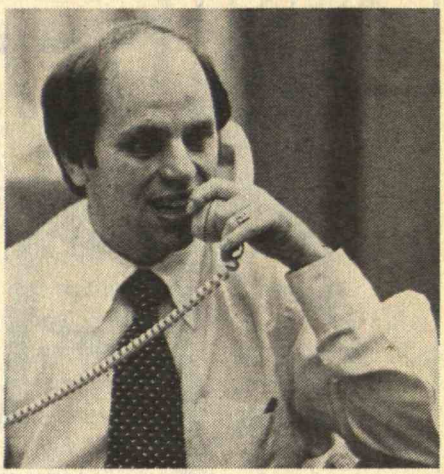


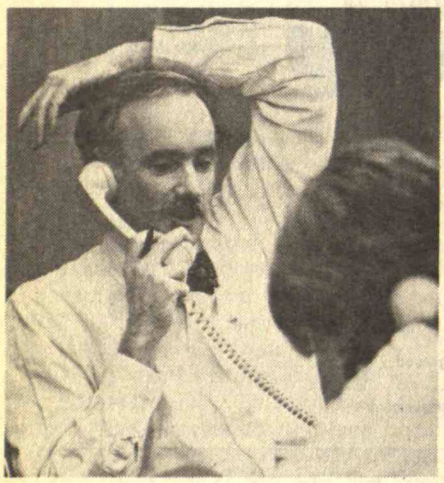
A How-to-Ask Course;
They Can Feel It When You Smile

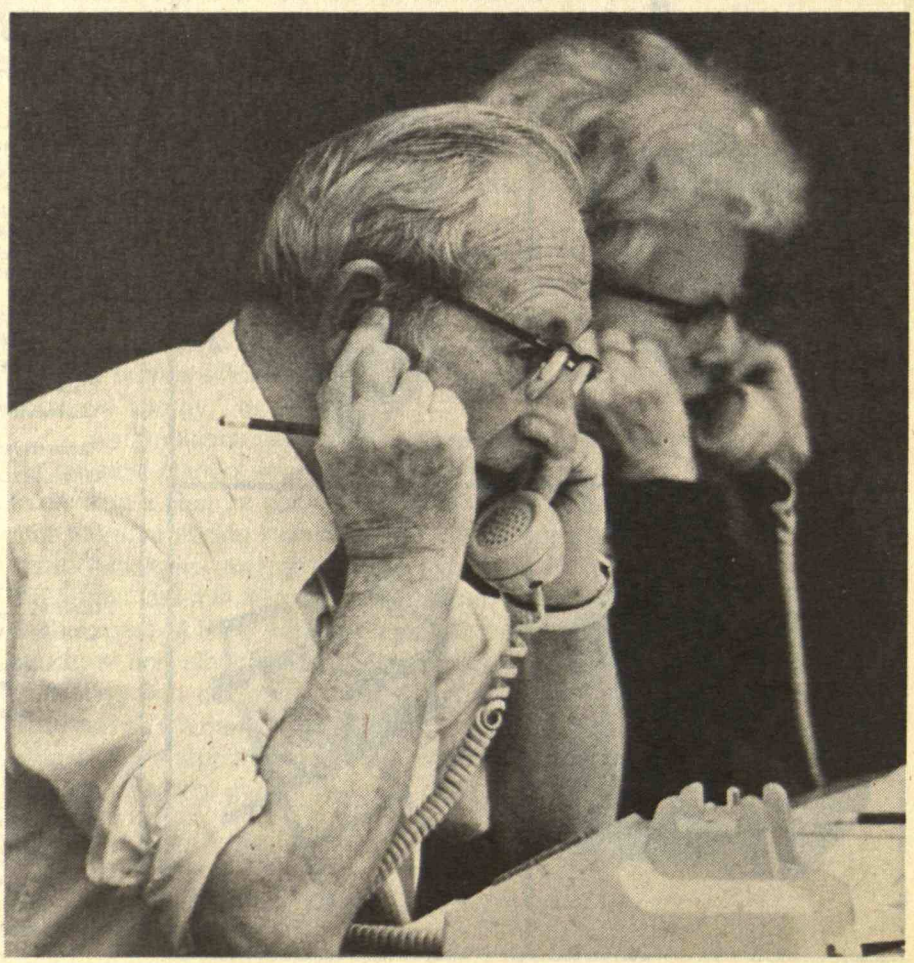
"He took too long to get to the point." "He sounds like me — embarrassed." "He should have been more persistent."

A group of alumni have just listened to a tape and are giving it a critique as part of a personal solicitation course. They dissect the process of asking for money.

Their goal is to convince some of their fellow-alumni who traditionally give under $100 to raise their contributions to M.I.T. Such "gift upgrading" is a major goal of the 1980 Alumni Fund: the median Alumni Fund gift is only $25, and the over $100 gift performance by the Fund is poorest among







Ivy League schools, explains Nancy Russell, Associate Director of the Alumni Fund and the course instructor. (Eighty per cent of total giving to M.I.T. comes from only 20 per cent of the donors.)

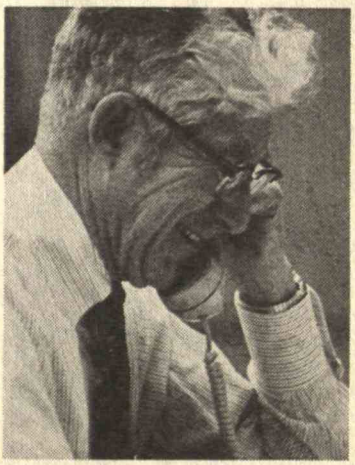
"Volunteers want to help, but they are hesitant," she explains. "How do I do it?" they ask. To answer their questions and assuage their discomfort, Ms. Russell worked with a consultant to develop the personal solicitation course. Volunteers agree to take the three-hour course as part of their training program. During the fall 140 alumni participated in one of 15 sessions.

It works. As a result of personal contact, gifts are bigger this year.

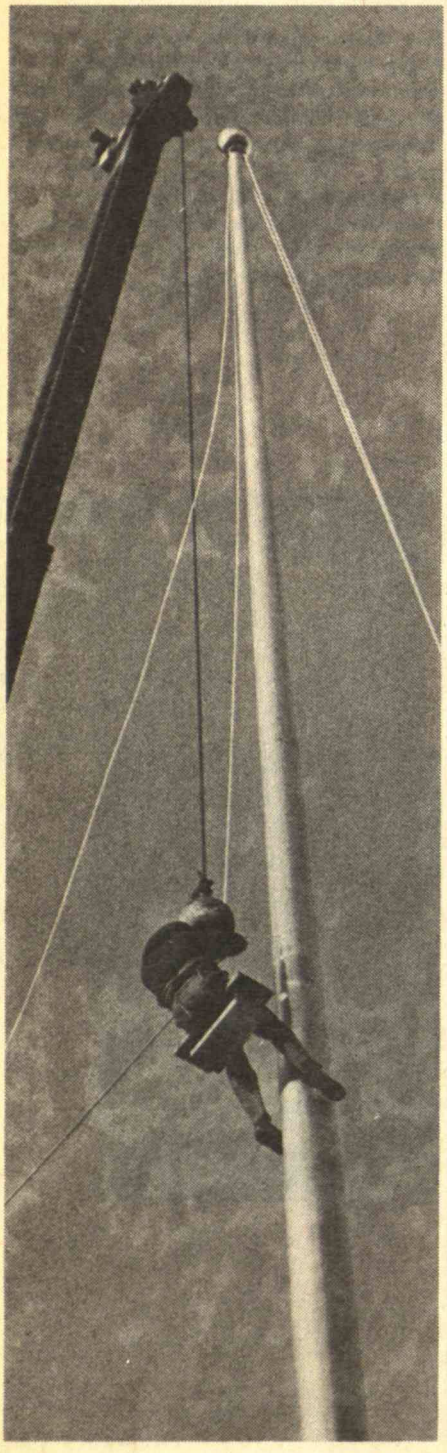
The course covers all bases: how to break the ice (establish a common ground; don't evaluate; listen and show interest; relate what the prospect has done to your own experience; make mental notes for later discussion); and frequently-raised objections to giving (too many current expenses; inflation; children in college; M.I.T. doesn't need money). The trainee learns how to answer (alumni financial support allows M.I.T. to subsidize the cost of education so students pay only about half; inflation also has laid a heavy hand on M.I.T.; the need for financial support is greater than ever), how and when to make the final "pitch" and how to be turned down gracefully.

Many of the suggestions in the course could be wisely used in any negotiations. Examples: Set your own goal (25 per cent higher contributions). Start high; then if necessary you can negotiate a compromise. Suggest a number, then relax — if you get no response, don't jump in with "well, how about . . ." Respond to any objections or reservations your prospect may have.

And when you pick up the phone to make that appointment, smile, says Ms. Russell. The person can feel it. — *M.L.*



Alumni in action at a fall "upgrading" telethon. Top, left: Stuart J. Vidockler, '66; this page: Joe M. Rife, '66. Bottom, left to right: Joseph M. Blew, '66, Mr. and Mrs. Walter J. Smith, '28, Charles G. Musselman, S.M.'75, Carol A. Catalano, '77, and Phoenix N. Dangel, '35. (Photos: Marjorie Lyon)



New guardians of the Killian Court.

For more than 60 years they stood tall and straight against even the strongest winds of New England hurricanes – the stems of truly superb 100-foot western pines, more than 60 inches around at the base. But time finally began to take its toll, and early in November a chain saw quickly and unceremoniously finished the task of bringing down the flagpoles erected to the design of Welles Bosworth, '89, in 1916. In their place, two brushed aluminum poles now carry the flags of the U.S. and the Commonwealth of Massachusetts – and just above them two 16-inch copper balls covered with gold leaf. (Photo: James E. Oker, '81, from The Tech*)*

Information and Decision Systems

It used to be the Servomechanisms Laboratory, a center for research in feedback control systems. Then it became the Electronic Systems Laboratory. Now it's changed once more: the Laboratory for Information and Decision Systems.

Professor Michael Athans, its director, says the new name reflects the laboratory's research interests: systems theory, control theory, communications networks, numerical analysis and algorithms, and complex systems analysis — and, within the latter, applications to automotive engines, transportation systems, aircraft control, flexible manufacturing systems, power networks, and the like.

All the research will continue to be "electronic" in nature, Professor Athans says. But there's increasing emphasis on human interfaces and measures of effectiveness.

60 Years of Pi Lambda Phi

The 60th anniversary of Pi Lambda Phi at M.I.T. will be celebrated at a three-day alumni reunion on February 16, 17, and 18, and more than 100 alumni members of the chapter are expected. Massachusetts Theta received its charter from Phi Beta Delta headquarters on February 28, 1920; and the current Theta chapter of Pi Lambda Phi is a direct outgrowth through merger with another national fraternity in 1941.

For further information write to Eric Brown at the Pi Lambda Phi house, 450 Beacon St., Boston, 02115; or call (616) 267-5451.

All Calm Among the Iranians

Among 1,688 foreign students (including 389 undergraduates) at M.I.T. this year, the 77 Iranian nationals have been the object of special concern. "We want to assure them that their continued presence as students on the campus is welcome and that they retain the confidence of their fellow-students and of the faculty," President Wiesner said at a fall faculty meeting.

Though 65 Iranian students at Harvard and M.I.T. stated soon after President Carter's directive that they would not follow its mandate to report to the Immigration and Naturalization Service "until the legality of that order was demonstrated," there was in fact no problem. Eugene Chamberlain, international student adviser, was assured that only a single personal visit to the service would be required of any student whose papers were in good order or who was only "in technical violation," and that the INS "would not be engaged in a 'witch hunt.' "

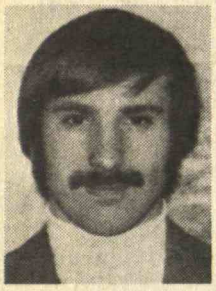
Placement: Walking in the Sun

Despite the clouds of inflation-borne recession lurking on the horizon, "right now we're walking in the sunlight," says Robert K. Weatherall, director of the Career Planning and Placement Office. Recruiting efforts by industry in 1979-80 show every sign of exceeding the record level of the previous year at M.I.T., Mr. Weatherall says. (The Deutsch, Shea, and Evans national recruitment index for high-technology engineers continued throughout the fall at a high level exceeded only once (1966) in the past 20 years.)

One reason for the traffic jam in the Placement Office, says Mr. Weatherall: "the ubiquity of the microprocessor. . . . Just about every other company that comes to us mentions the need to build microprocessor controls into its processes. Many have plans to increase their technical staffs over four-or five-year periods, no matter what the economy does. And so far industry is making good on those plans."

The Other Side
John Molitoris

On Art and Science



John Molitoris, '80, studies physics at M.I.T., where he is a member of the Heavy Ion Research Group. Though he enjoys writing about the philosophical and humanistic aspects of modern science, until now John has written mainly for himself and for The Tech.

"The most beautiful thing we can experience is the mysterious. It is the source of all true art and science."

from "What I Believe," in Forum *(October 1930), Albert Einstein*

Recently a friend of mine came up to Boston for a visit. She was an old friend from high school whom I had not seen for some time. In contrast to myself, she chose to develop her skills in the arts and went to a local liberal arts college rather than a "small, out of state, technical institution" like M.I.T. We spent some time touring the city and the Museum of Fine Arts before I decided that it was time to show her my *alma mater*.

I enjoy showing the Institute to people who visit me. Seeing M.I.T. day in and day out, I became so accustomed to the place that I take it for granted. But to see it through another's eyes is very interesting.

We eventually made our way to the Hayden Gallery and found the art exhibition entitled "Corners." I had a hard time relating to "Corners"; it had the same effect on me as a "Burnt Linoleum Art" exhibit I once saw at Berkeley. My sense was that this was not art. My friend could not relate to it, either, but she did state something interesting: there is work done in science which has the same effect on people as "Corners" had on me. To emphasize her point, my friend asked me if I could say that Einstein was any more a genius than Beethoven.

I think that there are basic distinctions one has to make between the two fields. For example, the artists at Berkeley who contributed to the "Burnt Linoleum" exhibit did not fail as artists. Although I had to laugh at those scraped, charred sections of someone's kitchen floor, I don't believe I had any right to say that they were not art. If it is burnt linoleum rather than marble that the artist chooses as a medium in which to express himself, then let it be burnt linoleum. Perhaps not many people understand burnt linoleum, and in that sense it may be unsuccessful art, but as long as it is the valid expression of the artist, it is art.

Expression in science is different. Ultimately, all works of science must be comprehensible, because science itself is based on the principle that nature is comprehensible. If no one but the theorist who discovered it is able to understand a theory, if the steps leading to it cannot be reconstructed, then one must question how valid that theory is. Also, science is forever driving toward the fundamental principles of nature: it has a definite goal. In the forefront of science, people are working in mediums that are clear and tangible. The creative genius of the scientist cannot be understood, but the clever methods, assumptions, and even the guesses, can.

It may be claimed that all works of art are comprehensible, but I think not — at least not in the same way one comprehends science. We can appreciate the aesthetic value of a scientific theory or marvel at the intricate forms of nature just as a painting or sculpture can be appreciated, but we cannot say that art and science are valid in the same sense or have the same goals. I would consider a work of art valid if the artist truly intended to express himself in the work. If the observer can find something in the work that he relates to, then it is art. The creative genius of the artist cannot be understood either, but like the scientist we can study the method and see what the crucial steps were. These steps are usually not as clear as those taken in science.

In both art and science each step adds to the whole, but in science each step can be very significant on its own. This is due to the very structure of science and the way science builds upon itself. Newton admitted that he stood on the shoulders of giants. The artist may decide to do something as an extension of a previous work, but he does not paint on the same picture or add a new section to Beethoven's ninth symphony.

In both fields it is the enduring qualities that act as the ultimate arbiter of how valid the work is. Theories come and go, but only the far-reaching ones will last. Paintings and sculpture come and go also, but only the works that each generation can relate to will last. Though each generation may find new meaning in works of science and art, there is a sense of timelessness. In science it may be some truth about physical reality while in art it is the human feeling which is conveyed. Man learns about nature through science; he learns about man through art. One can think of exceptions to this statement, but in general I believe it is true.

In a sense, art and science can be considered complementary. Indeed, there is art in science and science in art. At major universities one can study the "Physics of Piano" or the "Aesthetic value of Modern Science." Perhaps the two fields have a dual nature, and it just depends on how you look at it. How much of a physicist is a deaf man who can write symbols that can be translated into intricate and beautiful sounds? How much of a composer is a man who writes equations and formulas which state an equivalency of matter and energy? Role reversals of Beethoven and Einstein? I think not. Both men were very much a part of the physical world in which they lived and were very much in tune with that world; each was a scientist and an artist. Perhaps if they were not both, they could not have been either.

From Russia with Love

As the crowd pushed and packed into Room 10-250, I began to notice a distinct international flavor in the faces and dress of those around me. Boston's Russian community had received word that Boris Amarantov, "Russia's greatest mime," was performing at M.I.T. "I'm very sorry but you cannot sit in the aisles because of fire regulations," announced Julia Alissandratos, assistant professor in Foreign Language and Literature, who sponsored the performance. And quietly the few remaining seats were filled.

"Ladies and gentlemen: welcome to our show," said the tape recorded announcer used as background. "This show is called *Ki-La-La*, which has been forbidden in the U.S.S.R. *Ki-La-La* represents purity, kindness and sincerity; *Ki-La-La* comes from the heart."

In black tights with red umbrella and satchel, this master of body language proceeded to enchant and delight his audience. Children giggled aloud at the mischievous juggler. "He has taken a liking to your ways and your looks; he has given them life in himself," continued the tape recording. Pantomime, Mr. Amarantov had previously explained, is an ancient dramatic art concerned "with people, with goodness, with love." (I began to realize that it takes a special sensitivity and caring for people to skillfully mirror through expressions and postures their pains and their joys.)

In his role as *Ki-La-La*, the naive romantic and adventurer, Mr. Amarantov brings "miracles" in his red satchel; he is selling a free spirit philosophy, hope and the vibrance of life. "A clown," he says, "must wear a smiling face in spite of his life circumstances. And things *do* change." ("It may be that no one loves you today, but someone will tomorrow.")

Shifting to a more serious tone, Mr. Amarantov, in a vignette he called "Cranes" imitated free birds resisting tyranny, using powerful, sweeping, fluid motions — a metaphor for soaring hope. Here he combined delicacy with strength, and the real discipline of his art became apparent.

Having trained at the Choreographic Academy of the Bolshoi Ballet and the Academy of Circus Arts in Moscow and with

Boris Amarantov, Russian mime, performing at M.I.T. Photos: Daryl Kahn.

over 250 appearances at the Kremlin palace to his credit, Mr. Amarantov recently emigrated to the U.S. in search of freedom of artistic expression. Does mime cross cultures easily? Mr. Amarantov is working on this: he closed the performance with a newly created act, an imitation of a very American hero — Elvis Presley. — *S.K.*

The President-Designate Prepares: "It's Slippery Out There!"

What's it like to be president-designate of M.I.T.?

Less than a month after he was named to succeed Jerome B. Wiesner next July 1, Paul E. Gray, '54, chancellor, answered the question by recounting a story for members of the new M.I.T. Club of Westchester County at their inaugural meeting:

The first contestant in a figure-skating contest skated onto the ice, took a few strides, and suddenly slipped and fell, sliding across the ice and crashing into the boards in front of the judges' stand. Inevitably, the scores were 0, 0, 0 and . . . 8.2. The first three judges turned to the fourth in consternation, but he explained: "You've got to remember — it's very slippery out there."

Since then Dr. Gray has eschewed almost all public activities which respond to his role as president-designate. His responsibilities as chancellor "continue without significant change," he recently wrote an alumni club where he'd been invited to speak, "and I am trying very hard to find sufficient time to be thoughtful and reflective about the problems of the future. . . . The pressures on my time," he said, seem to be "particularly intense."

Perhaps the most demanding of the issues now on his desk are related to finances, Dr. Gray told the Westchester alumni. Though the $225 million goal of the Leadership Campaign has been exceeded (*see page A8*), he said, that goal was set in terms of 1975 dollars, and there are therefore still major needs to be met.

And Dr. Gray commented on one aspect of the Alumni Fund as a cause of concern: the median gift is $26 per year — "a shockingly small number," he said. Only 19 per cent of gifts to the 1979 fund were $100 or higher.

When he's asked how alumni should relate the Institute's needs to their own circumstances and arrive at a gift amount, Dr. Gray replies in terms of what he calls the "hidden scholarship" which every alumnus has received from the Institute. Over many years, he points out, the cost of education at M.I.T. has been about twice the amount of tuition. It's that difference which represents the "hidden scholarship," and appropriate levels of giving from former students will assure that today's and tommorow's students can have a similar benefit when they come to Cambridge.

In the Subway, On the Bridge?

The subway station in Kendall Square will soon have a new name: Kendall/M.I.T., just as the Charles Street Station on the same M.B.T.A. "red" line has been renamed Charles/M.G.H. Upon hearing this news, *The Tech* reopened the decades-old project of giving the Harvard Bridge (across the Charles River in front of the Institute) a title more appropriate to its geography.

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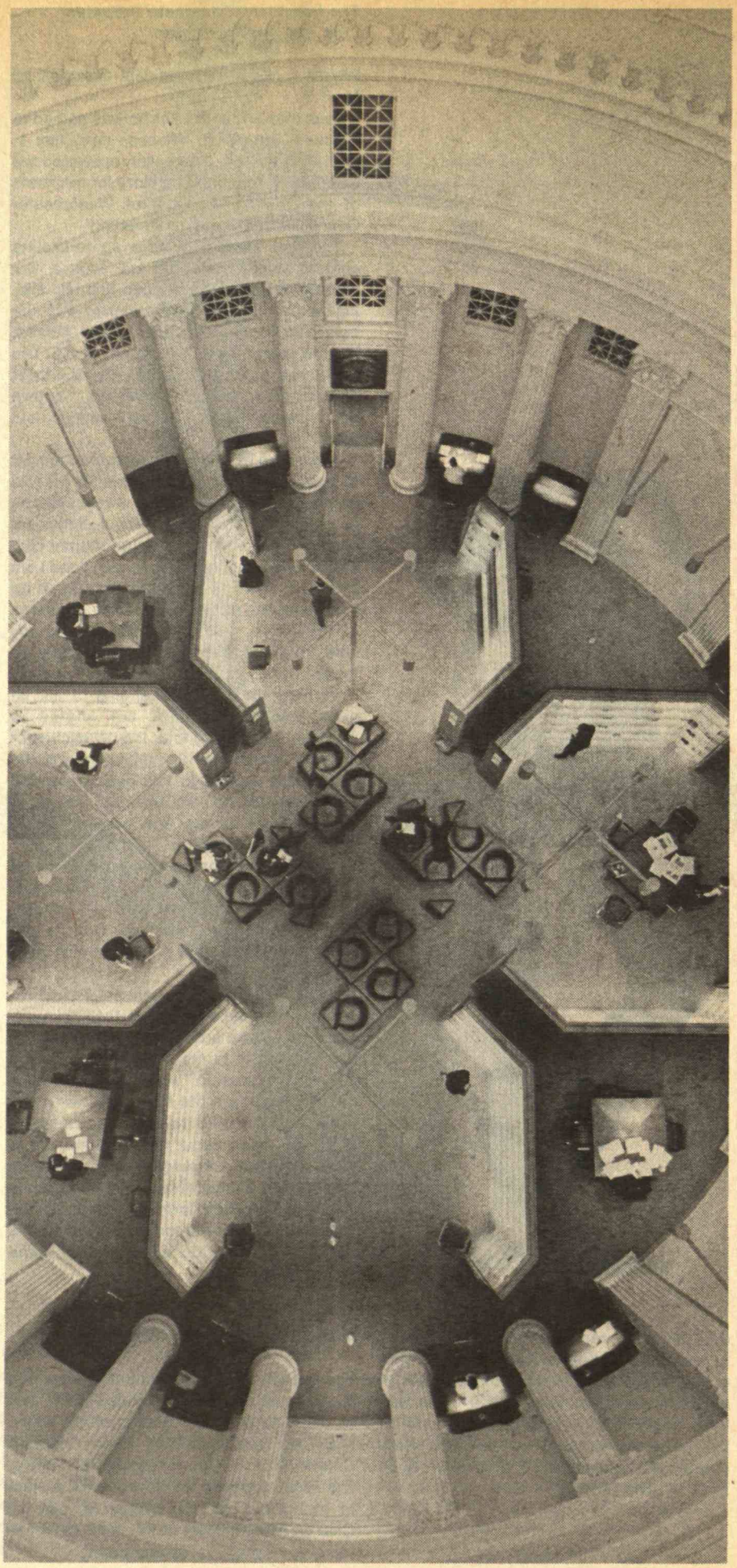
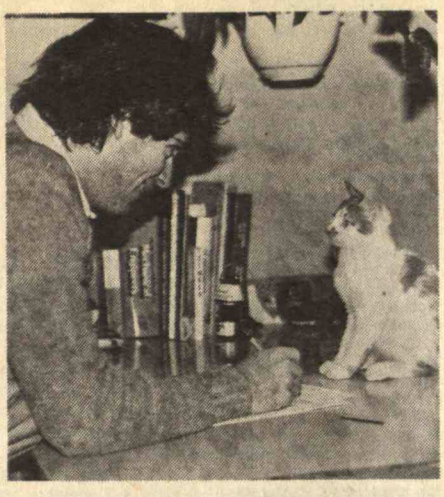
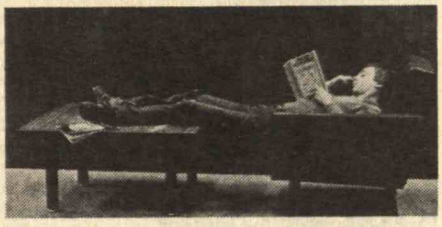
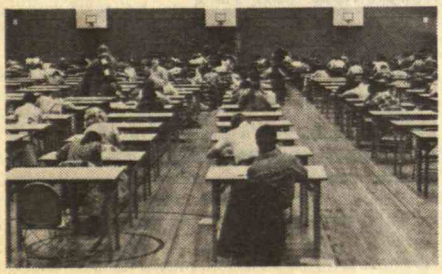








Finals, an essay by James J. Snyder. '80, courtesy of Technique.

Opposite page: Barker Engineering Library in Building 10. Photo: Black Star

Life Members of the Sustaining Fellows

The following have accepted (as of November 7, 1979) M.I.T.'s invitations to be founding life members of the M.I.T. Sustaining Fellows. Life membership is limited to those whose cumulative giving to M.I.T., for any purpose, exceeds $25,000.

Lester A. Ackerman, '48
E. Rudge Allen, '48
Paul W. Allen, '37
Bennett Archambault, '32
David F. Austin
Mr. and Mrs. Julian M. Avery, '18
Dr. Yaichi and Mrs. Masako Ayukawa, '52
Mr. and Mrs. Jonathan Y. Ballard, '23
Dr. Maurice E. Barker, '29
Armand Bartos, '35
Mr. and Mrs. Walter J. Beadle, '17
Mr. and Mrs. Leo M. Beckwith, '35
Peter S. Bing
Philip D. Blanchard, '24
Mr. and Mrs. Edward L. Bowles, '22
Benjamin H. Bristol, '19
A. Raymond Brooks, '17
Dr. and Mrs. Gordon S. Brown, '31
George M. Bunker, '31
Mr. and Mrs. Royden L. Burbank, '19
Homer A. Burnell, '28
Mr. and Mrs. John H. Bush
Mr. and Mrs. Thomas D. Cabot
John M. Campbell, '25
Donald F. Carpenter, '22
Alanson W. Chandler, '37
Ralph B. Chapin, '37
J. Russell Clark, '29, and Mrs. Dorothy I. Clark
Dr. and Mrs. Dayton H. Clewell, '33
Philip L. Coleman, '23
Randolph P. Compton
Mr. and Mrs. Paul M. Cook, '47
William A. Coolidge
Arthur J. Connell, '27
Thomas F. Creamer, '40
Dr. and Mrs. Colgate W. Darden, III, '59
Mr. and Mrs. Alexander D. Daunis, '32
George S. DeArment, '37
Ray P. Dinsmore, '14
William E. P. Doelger, '26
Pierre S. du Pont, '33
Willis H. du Pont
George P. Edmonds, '26
James M. Ewell, '57
Whitworth Ferguson, '22
The Honorable Luis A. Ferré, '24
Mr. and Mrs. Harold W. Fisher, '27
Ralph A. Fletcher, '16
Daniel F. Flowers, '41
Fred Fort Flowers, '41
Mr. and Mrs. Marshall Wren Gabel, '39
Mr. and Mrs. H. W. Gadsden
Walter H. Gale, '29
Robert W. Galvin
Mrs. William W. Garth, Jr.
Mr. and Mrs. Kenneth J. Germeshausen, '31
Mrs. Edwin R. Gilliland
Anthony H. Gleason
Mrs. Jacob A. Goldfarb
Barnett D. Gordon, '16
Bernard M. Gordon, '48
Mr. and Mrs. Haskell R. Gordon, '38
Dr. and Mrs. Cecil H. Green, '23
Crawford H. Greenewalt, '22
Samuel A. Groves, '34
Ernest A. Grunsfeld, III, '52
Robert C. Gunness, '34
John C. Haas, '42
Mr. and Mrs. Edward J. Hanley, '24
Marion Hanny
C. J. Harrington, '38
William E. Hartmann, '37
Mr. and Mrs. Warren J. Henderson, '33
William R. Hewlett, '36
E. W. Hiam, '48
Henry W. Hills, '20
Oscar H. and Mrs. Mary C. Horovitz, '22
Mr. and Mrs. Albert J. R. Houston, '22
Jerome C. Hunsaker, '12
Dr. and Mrs. Cuthbert C. Hurd, '59
Elmer C. Ingraham, '26
Irving D. Jakobson, '21
J. K. Jamieson, '31
Mr. and Mrs. Howard W. Johnson
Dr. and Mrs. Alan F. Kay, '48
Fred Kayne, '60
I. Austin Kelly 3D, '26
Breene M. Kerr, '51
Mr. and Mrs. John W. Kilduff, '18
Dr. and Mrs. J. R. Killian, Jr., '26
John R. Kimberly, '26
Charles G. Koch, '57
David H. Koch, '62
Dr. and Mrs. David I. Kosowsky, '52
Betty and Max Kranzberg
Mrs. Geraldine S. Kunstadter, '49
John W. Kunstadter, '49
Dr. and Mrs. Ralph Landau, '41
Stanley M. Lane, '17
Mr. and Mrs. Allen Latham, Jr., '30
Mr. and Mrs. Norman B. Leventhal, '38
James A. Levitan, '45
Dr. and Mrs. Yao Tzu Li, '38
Mr. and Mrs. Ellis C. Littmann, '33
Carl M. Loeb, Jr., '28
Leo Loeb, '08
Samuel E. Lunden, '21
Mr. and Mrs. Floyd A. Lyon, '42
Angus N. MacDonald, '46
Mr. and Mrs. Claude F. Machen, '31
Lois and Philip Macht, '48
Jan W. Mares, '60
Leonard and Arlene G. Mautner, '39
Mr. and Mrs. Malvin J. Mayer, '33
Henry J. McCarthy
Charles B. McCoy, '32
H. W. and Mrs. S. Catharine McCurdy, '22
W. Wallace McDowell, '30
Denman K. McNear, '48
Robert E. Meyerhoff, '44
E. Kirkbride Miller, '41
J. Irwin Miller
Theodore T. Miller, '22
Frank R. Milliken, '34
William H. Mills, '34
Jean Montagu, '55
Richard S. Morse, '33
Mr. and Mrs. Carl M. Mueller, '41
Robert A. Muh, '59
Mr. and Mrs. W. B. Murphy
W. L. Newhall, '22
Mr. and Mrs. Eric P. Newman, '32
William H. Nichols, Jr.
John W. Norris, Sr., '27
Mr. and Mrs. Harold S. Osborne, '08
Mr. and Mrs. Dexter T. Osgood, '29
Thornton W. Owen, '26
Howard W. Page, '27
Alfred E. Perlman, '23
Mr. and Mrs. Edward J. Poitras, '28
Mr. and Mrs. Saul Poliak
Mr. and Mrs. Stanley M. Proctor, '43
Charles E. Reed, '37
John L. Riegel, '19
Mr. and Mrs. Antonio Helier Rodriguez, '21
Cornelius Van S. Roosevelt, '38
Robert B. Semple, '32
Mr. and Mrs. Harold R. Seykota, '39
Mr. and Mrs. David A. Shepard, '26
Mrs. George Warren Smith
Mr. and Mrs. Walter J. Smith, '28
Roger and Joan Sonnabend, '46
Walter W. Soroka, '30
Mr. and Mrs. Samuel R. Spiker, '09
Mr. and Mrs. Louis E. Stahl, '36
Mrs. Edmund R. Stearns
Mr. and Mrs. Francis E. Stern, '16
Dr. and Mrs. Julius A. Stratton, '23
Mr. and Mrs. Martin Y. Tang, '72
Mr. and Mrs. John F. Taplin, '35
L. G. L. Thomas, '20
Paul Tishman, '24
Howard S. Turner, '36
James E. Turner, '33
Mr. and Mrs. Karl R. Van Tassel, '25
C. Vincent Vappi, '49
Mr. and Mrs. Edward O. Vetter, '42
George R. Vila, '33
Mr. and Mrs. Philippe Villers, '60
Dr. and Mrs. Alan M. Voorhees, '49
Mrs. Emily V. Wade, '45
Jeptha H. Wade, '45
Mr. and Mrs. James P. Warner, '26
Max Wasserman, '35
James L. and Mrs. Faith P. Waters, '26
Mr. and Mrs. William J. Weisz, '48
Robert Welles, '15
Mr. and Mrs. Thomas H. West, '22
Mrs. Uncas A. Whitaker, '23
Dr. and Mrs. Jerome B. Wiesner
John J. Wilson, '29
Lester Wolfe, '19
Abraham Woolf, '28
Charles C. Wyatt, '32
Mr. and Mrs. Frank S. Wyle, '41
Mr. and Mrs. Charles Ying, '67
Richard Ying, '68
Jerrold R. Zacharias
Leona Zacharias
Alejandro Zaffaroni
William R. Zimmermann, '48

Sustaining Fellows: A New Incentive for Unrestricted Giving

A new form of involvement with M.I.T. — Sustaining Fellows — was announced last fall at the annual meeting of the Development Committee of the M.I.T. Corporation.

The idea, said Howard W. Johnson, chairman of the Corporation, is to increase the involvement in M.I.T. of those whose support and commitment "make them valued members of the M.I.T. community"; and to "draw into M.I.T." others who want to have this closer relationship with the Institute.

Two forms of participation were specified by Mr. Johnson:

☐ Regular members of the Sustaining Fellows are those who make annual gifts of $2,000 or more for unrestricted purposes or for endowment to support general purposes, scholarships, or professorships.

☐ Life members are those who have made cumulative gifts of $25,000 or more for any purpose. Many alumni have already accepted designations as founding life members. *(see the list on this page).*

Breene M. Kerr, '51, is chairman of the program, and Professor Elias P. Gyftopoulos, Sc.D.'58, is its faculty chairman. Together they will arrange special programs for fellows as well as seminars and campus visits; Eric C. Johnson, '67, formerly assistant director of the Industrial Liaison Program, will provide staff support as director.

Andrey A. Potter, 1882-1979

Andrey A. Potter, '03, who was dean of the School of Engineering at Purdue University for 33 years before retiring in 1953, died in Lafayette, Ind., on November 5; he was 97.

Professor Potter joined the mechanical engineering faculty at Kansas State College soon after completing his studies at M.I.T.; by 1913 he was dean of engineering there — a position which he held until going to Purdue in 1920. Twice Dean Potter refused the presidency of Purdue, preferring to stay in the professional field of his chooosing; but on both occasions he took the presidency on an interim basis until a new president was selected.

He was a major figure in the American Society of Mechanical Engineers and in the field it serves, adding consulting work to his burden of teaching and administrative assignments at Purdue. Following his retirement from Purdue he served for ten years as president of the Bituminous Coal Research Corp.

Robert Holz, 1937-1979

Robert Holz, '58, who was a member of the staff of the Registrar's Office and the Office of Institutional Studies between 1959 and 1967, died on September 8; he was 42. He was a resident of Bellingham, Wash., when he died.

I
Civil Engineeering

Horace Schow II, S.M. '61, reports that he passed the patent bar exam and became a registered patent attorney in August, 1979; he received his J.D. degree in 1977 and became a member of the Florida Bar in 1978. . . . **Douglas H. Merkle,** Ph.D. '71, is currently the TRESTLE program manager at the Air Weapons Laboratory, Kirtland AFB, N.M.

Thomas W. Brockenbrough, S.M. '46, was named Delaware's Engineer of the Year for 1979. He was honored on February 20 by the Delaware Society of Professional Engineers at the annual engineer's week banquet at the University of Delaware. He is the 22nd recipient of this award and only the second educator to receive it since it was initiated. He is a member of the civil engineering faculty at the University of Delaware.

W. Carter McClure, S.M. '38, notes that he retired last December 31 after 33 years of consulting work for the pulp and paper industry. . . . **Keith D. Stolzenbach,** Ph.D. '71, associate professor of civil engineering at M.I.T. has been awarded the American Society of Civil Engineers' Walter L. Huber Research Prize. He was cited for his "research on measurement and modeling of heated discharges associated with electric energy generation."

II
Mechanical Engineering

David Scott Nichols, S.M. '72, is presently chief resident in opthalmology at Brook Army Medical Center, San Antonio, Tx. . . . **James Fleischhacker,** S.M. '68, has been promoted to manager, Flex Products, for A.M.P., Inc. . . . **Paul N. Estey** is presently working for the Jet Propulsion Laboratory in Pasadena, Calif. He has been engaged in propulsion systems analysis for the two *Voyager* spacecraft as well as designing a unique liquid fuel feed system which is expected to be used on future deep space missions.

Betty Woody is currently a member of the Committee on Pest Management, National Academy of Sciences. . . . **Henry P. Morgan,** Sc.D. '48, professor of management policy and director of the Master of Business Administration Program at Boston University, has been appointed Dean *ad interim* of the School of Management.

Major awards of the American Society of Mechanical Engineers came to nine members of the M.I.T. community during A.S.M.E.'s 1979 winter annual meeting in New York in December:

☐ To **Arthur E. Bergles,** '57, chairman of the Mechanical Engineering Department at Iowa State University, Ames, the Heat Transfer Memorial Award for "unique contributions in bridging between heat transfer fundamentals and heat transfer practice; bringing order to the pursuit of heat transfer augmentation; and enriching the archival literature in the areas of boiling, two-phase flow, duct flow, and conduction."

☐ To **Louis F. Coffin, Jr.,** Sc.D. '49, of General Electric Co., Schenectady, N.Y., the Nadai Award "for pioneering studies and analysis defining the fatigue performance of engineering materials especially under high cyclic strain conditions, and for his contributions in plasticity, metal working, material testing, and tribology."

☐ To **Bruce G. Collipp,** , '52, senior staff engineer at Shell Oil Co., Houston, the Holley Medal for "conception, design, and development of the column-stabilized semi-submersible drilling vessel and mooring systems . . . and for continuing contributions to the technology of deep-water drilling platforms and mooring systems."

☐ To **Robert C. Dean, Jr.,** '48, president of Verax Corp., Hanover, N.H., the Fluids Engineering Award for his "outstanding leadership in extending the frontiers of useful fluids engineering knowledge; his writings, which are frequently cited as prime references in turbo machinery literature; and his contributions as editor of the *Journal of Fluids Engineering*."

☐ To **Jacob P. Den Hartog,** professor of mechanical engineering, emeritus, the A.S.M.E. Medal "for pioneering and establishing the art and science of vibration analysis as an integral component of the practice of mechanical engineering in this country and much of the rest of the world."

☐ To **Edward M. Greitzer,** associate professor of aeronautics and astronautics (with Ivor J. Day of Pretoria, South Africa, and Nicholas A. Cumpsty of the Jet Propulsion Laboratory), the Gas Turbine Award for a contribution to the literature of combustion in gas turbines and their utilization in combination with nuclear or steam power plants.

☐ To **Henry M. Paynter,** professor of mechanical engineering, the Rufus Oldenburger Medal for "creative accomplishments in all aspects of dynamic systems theory and practice, especially fluid transients, simulation methodology, and the bond graph language; his inspiring example to students and colleagues; and his supreme enthusiasm."

☐ To **Kenneth A. Roe,** '41, chairman and president of Burns and Roe, Inc., Oradell, N.J., the Edwin F. Church Medal "for his eminent service in increasing the value, importance, and attractiveness of mechanical engineering education and his outstanding leadership in professional society activities and direct university interactions, contributing significantly to improving mechanical engineering education."

III
Materials Science and Engineering

Roger W. Powell, Ph.D. '74, has been appointed manager of alloy properties at Westinghouse Hanford Corp., Richland, Wash. . . . **John F. Wallace,** S.M. '41, chairman of the Department of Metallurgy and Materials Science of Case Institute of Technology, has been appointed the Republic Steel Professor of Metallurgy. The Republic Steel chair was established in 1956 with funding from

First Black Woman Earns Sc.D. in Chemical Engineering

An Alabama woman who has received the Sc.D. from M.I.T., becoming the first black woman in the U.S. to earn a doctoral degree in chemical engineering, says two of her best teachers never went past the sixth grade.

Jennie Patrick-Yeboah was referring to her parents, Mr. and Mrs. James Patrick of 201 Keeling Road, of Gadsden, Ala. They taught their five children that education was the one sure way to free themselves from the economic hardship the older Patricks had faced.

Dr. Patrick-Yeboah, her two brothers and two sisters learned that lesson well. The new M.I.T. degree holder is now an engineer in the chemical energy systems and processes branch of General Electric's Corporate Research and Development Center in Schenectady, N.Y. One brother is a surgeon, the other has a degree in management. One sister is a nurse, the other has a degree in finance.

"Our parents didn't want us to relive their lives, didn't want us to re-experience what they had gone through," Dr. Patrick-Yeboah said. "They had to leave school at the sixth grade. My mother worked as a maid, my father as a janitor. They always stressed that education would free us from all that. Mom and Dad were very supportive of all of us and had to live very disciplined lives in order to buy us things like encyclopedias. We all owe them so much."

Continued on page A22

Dr. Patrick-Yeboah came to M.I.T. in 1973 after receiving the B.S. in chemical engineering from the University of California, Berkeley. She had transferred there from Tuskegee Institute when that school's program in chemical engineering was disbanded.

Deciding on a career in chemical engineering was in keeping with the educational philosophy Jennie Patrick worked out for herself as a high school student: avoid the easiest way through because it may not be the most rewarding.

"I was always interested in science. Whatever was more challenging interested me the most in high school. Chemical engineering attracted me for the same reason."

As a woman who has succeeded in a field that has attracted few females, and as a black woman who has had to face prejudice and discrimination, what advice would she offer to those who might follow her path?

"The most important thing is confidence and being somewhat independent in thought. Most of the time what matters is emotional strength, one's ability to endure, rather than whether one has intelligence or not. For a black woman, the first issue is racism; the fact of being a woman becomes secondary.

"The best advice I can give a young girl is to be positive about herself and her capabilities and to set her own standards in terms of what she wants to achieve. Then use only those standards as levels to strive for. Never allow anybody else to arbitrarily set standards for you. Those standards are usually far below what you would set for yourself. Don't let others establish your potential."

Dr. Patrick-Yeboah's doctoral thesis at M.I.T. involved a study of superheated limit-temperatures of non-ideal binary mixtures and pure components. Her work led to new insights into the behavior of vapor explosions.

"I was able to discover that a liquid fluorocarbon that had previously been used primarily as a lubricant for space missions had applications as a heating medium in studying superheated liquids." Her discovery opened up new research approaches which enabled her to report for the first time experimental superheat-limit temperatures of several complex mixtures and their pure components.

Her thesis adviser was Professor Robert C. Reid, internationally recognized as an expert on the behavior of liquefied natural gas and vapor explosions.

The National Organization of Black Chemists and Chemical Engineers says that Dr. Patrick-Yeboah is the first female member of her race to achieve a doctoral degree in her field. She also may be involved in another "first"—the most M.I.T. degrees held by a married couple. The number is six.

Her husband, Yaw D. Yeboah, whom she met shortly after coming to M.I.T., earned four degrees in 1975—the S.B. in chemistry, chemical engineering and management, and the S.M. in chemical engineering. Last June, Dr. Yeboah, a native of Ghana, received the Sc.D. in chemical engineering. He also is employed by General Electric in Schenectady.—*Robert C. Di Iorio*

John T. Marvel

Albert C. Zettlemoyer

the Republic Steel Corp.'s education and charitable trust.

Steven S. Hansen, S.M. '73, recently prepared a technical paper entitled "The Effect of Temperature and Composition on the Power Requirements of Hot Strip Mill Roughing Stands," for the Bethlehem Steel Corp. The paper was presented at the recent 21st annual Mechanical Working and Steel Processing Conference, Cleveland, Ohio. . . . **David A. Thomas,** Sc.D. '58, professor of metallurgy and materials engineering at Lehigh University, has been granted a leave of absence for the 1980-81 academic year to work in the research program of the Technology National Bureau of Standards, Gaithersburg, Md.

V
Chemistry

Edward R. Kane, Ph.D. '43, announced his retirement as president of the Du Pont Co. after serving in the office since 1973. He has been awarded the International Palladium Medal of the Societe de Chimie Industrielle for his contributions to the chemical industry worldwide. . . . **Robert L. Hance,** Ph.D. '70, has been promoted to professor of chemistry at Abilene Christian University, after having spent the past academic year at the University of Texas at Austin as visiting professor of chemistry.

J. T. Wasson, '58, professor of geochemistry and chemistry at U.C.L.A., reports his presidency of the Meteoritical Society. . . . **Alex Bonilla Certes,** Ph.D. '72, passed away on April 15, 1979. He had worked for seven years as a professor in the Department of Chemistry at the University of Puerto Rico, Rio Piedras campus. . . . **John C. Stowell,** Ph.D. '64, associate professor of chemistry at the University of New Orleans, recently wrote *Carbanians in Organic Synthesis*, published by John Wiley and Sons, Inc. The book, for practicing and research chemists, describes the preparation, reaction and applications of carbanians.

James T.B. McKnight, Ph.D. '53, reports, "I wonder how many father-daughter M.I.T. Ph.D.'s there are. I received mine in organic chemistry in 1953, a few months after my daughter Diane was born. Diane finished work on hers in the field of water resources this past summer." . . . **John T. Marvel,** Ph.D. '64, has been named director of Monsanto Agricultural Products Co.'s Reseach Department.

Manson Benedict, Ph.D. '32, has been honored by the nuclear community with the Henry DeWolf Smyth Nuclear Statesman Award. The award recognized outstanding service in developing and guiding the uses of atomic energy in constructive channels. . . . **Albert C. Zettlemoyer,** Ph.D. '41, provost and vice president of Lehigh University, has been chosen president-elect of the American Chemical Society for the 1980 term.

VI
Electrical Engineering and Computer Science

Edward W. Kimbark, Sc.D. '37, has been chosen as the recipient of the William M. Harbirshaw Award of the Institute of Electrical and Electronic Engineers for 1980, which will be presented on February 5 at the winter meeting of the I.E.E.E. Power Engineering Society in New York City.

Klaus B. Bartels, S.M. '75, since August 1 has been assigned to Griffis AFB, N.Y., as a communications/electronics engineer. While stationed in Turkey, July 1978 through July 1979, he received an Air Force commendation medal for meritorious service. . . . **Clarence Zicko,** S.M. '59, has been appointed division manager of microelectronics at Analog Corp. . . . **Robert Price,** Sc.D. '53, has been with the Sperry Rand Research Center, since 1965, where he is now staff consultant for communication sciences, presently engaged in telecommunications systems engineering. He continues as a major advisor on the innovative disk file families being produced by Sperry Univac ISS.

IX
Urban Studies and Planning

Professor **Lisa R. Peattie** was arrested (her case was later dismissed) outside the New York Stock Exchange last October 29, on the 50th anniversay of the "great stock market crash" of 1929. She was one of more than 1,000 pulled off the streets by New York police during the nonviolent demonstration.

Most observers took the episode as a demonstration against future investments in nuclear power. But Professor Peattie's interpretation (for Jeffrey Cruikshank, editor of the department's newsletter) is that "people were trying to take what is perceived of as a white, middle-class, ecology-oriented movement (against nuclear power) and make out of it a movement which speaks to the concerns of both the ecology movement and the more traditonal radical left.

"I'm educating myself," Professor Peattie explained, noting the dissimilar roles of the activist and the academic. "We professors assume that action comes out of theory, but it isn't and shouldn't be that way exclusively. We should also admit that understanding comes out of action."

Laura B. Clausen, M.C.P. '64, assistant secretary of educational affairs for the Commonwealth of Massachusetts, was elected chancellor of the State Board of Higher Education. As chancellor, she will direct the twelve-member board, which is responsible for state-wide planning and coordination of educational policies in the Commonwealth. All public institutions of higher learning, as well as the 55 private colleges and universities in the state, are under the direction of the board.

M. N. Hochman, M.C.P. '74, is involved in

Meyer Joins Computer Science

Albert R. Meyer, Professor of Electrical Engineering and Computer Science, is now Associate Director of the Laboratory for Computer Science, succeeding Professor **Joel Moses,** Ph.D. '67.

As Associate Director, Professor Meyer will continue to lead the largest research effort in the Laboratory, the theory group; he's made important contributions through that group to understanding computational complexity and the limits of computation. He's a graduate of Harvard in applied mathematics, and he's taught at M.I.T. since 1975; earlier assignments were at the University of Warwick, England; the University of California, Berkeley; and Carnegie-Mellon University.

Professor Moses is now Associate Head for Computer Science of the Department of Electrical Engineering and Computer Science.

neighborhood economic development plans for older, small cities in the Northeast and Midwest.

X
Chemical Engineering

Chong Y. Yoon, Sc.D. '59, has been promoted from group manager of fermentation products production of the Upjohn Co., to director of fine chemical production. He joined the Upjohn Co. 20 years ago as a junior scientist. . . . **Harris J. Bixler,** Sc.D. '59, has been named president of Avco Everett Research Laboratory, Inc., Everett, Mass. . . . **John P. Longwell,** Sc.D. '43, professor of chemical engineering at M.I.T., has been named the recipient of the 1979 Chemical Engineering Practice Award given by the American Institute of Chemical Engineers. The award recognized outstanding contribution to the industrial practice of chemical engineering.

XII
Earth and Planetary Sciences

Milo M. Backus, '52, professor of geophysics at the University of Texas, Austin, is president-elect of the Society of Exploration Geophysicists for 1979-1980. . . . **Martin J. Buerger,** '25, Institute Professor Emeritus, has been invited to give a series of lectures on "homometric sets" at the Aristotle University of Thessaloniki, and plans to spend some time in Greece early in 1980.

Gerald L. Schroeder, '59, who has been working with the Ministry of Agriculture in Israel for the past few years, recently returned to the United States with his wife and three children, and is presently employed by A. D. Little, Inc., in Cambridge. He is interested in developing aquacultural programs for countries that are protein-deficient. . . . **Regina V. Spirn,** '66, is working as analytical research chemist at Halcon Research and Development. Her husband, Rabbi Charles A. Sprin, has assumed the position of Head Chaplain of Mt. Sinai Hospital in New York City. . . . **M. L. Jensen,** '51, recently completed a third edition of a leading textbook, *Economic Mineral Deposits* (John Wiley and Sons, Publisher); sharing authorship with the book's original author, A. M. Bateman. Jensen is now professor of geology at the University of Utah.

Thomas R. McGetchin, a former member of the department from 1969 to 1974, died of abdominal cancer on October 22, 1979, in Queens Hospital, Honolulu, Hawaii, after a prolonged illness. He had been presented the NASA Public Service Award only a few weeks before his death. Mrs. McGetchin and the three children now live at 27 Woodbine Ave., Barrington, R.I., 02890. . . . **Harold J. Noyes,** Ph.D. '78, is currently involved in applying geochemistry to the search for metal deposits throughout western North America; from Mexico to Alaska. — **Robert R. Shrock,** Room 54-1026, M.I.T.

XV
Management

Adrian Weaver, S.M. '57, director of product safety for the IBM Corp., had been re-appointed vice chairman of the United States Metric Board. He is a former chairman of the American National Metric Council, a private organization designed to plan, coordinate, and implement the voluntary change to the metric system. . . . **Denis M. Slavich,** Ph.D. '71, is a vice president of B.F.S.I. and manages project financing and investments in finance, overseeing the analysis of financial conditions, economic feasibility reports and review and monitoring of current investments. . . . **Donald A. Dick,** S.M. '68, is vice president — division operations of the A.E.P. Service Corp.

Jay W. Forrester, S.M. '45, Germeshausen Professor of Management at M.I.T., was recognized by Governor Edward J. King for the impact he has made through science and technology on improving the quality of people's lives. Two days later, he received the first Common Wealth Awards of Distinguished Service. . . . **Phyllis A. Wallace,** professor of management in the Sloan School of Management, was one of 18 persons named to the Carter administration's Pay Advisory Committee, designed to help fight inflation.

Donald V. Fites, S.M. '71, has been elected president of Caterpillar Brasil S.A. . . . **Eric L. Herzog,** Ph.D. '73, is beginning his second year as a management consultant. His work includes

Wealth for Unleashing Risk-Taking

Invention is only the first half of innovation. The second half — by far the more expensive of the two — is entrepreneurship, the business of making an invention useful and profitable.

And our problem today, says **Ralph Landau,** Sc.D. '41, is that resources and incentives for entrepreneurship are dwindling under the impact of inflation, taxes, regulation, and federal deficit policies.

"In my opinion, . . . money in the private sector (capital and incentives for its formation) is the key to unleashing technology," writes Dr. Landau in *Chemtech* (January, 1979).

"There has to be a recognition at the highest levels in the U.S. that a trade-off is necessary between encouraging new risk-taking wealth among corporations and individuals — wealth that will translate into investments — and the desire for equity and redistribution of income. This trade-off will have to be settled largely in the direction of wealth creation and new entrepreneurial incentives by tax reduction and regulatory reasonableness.

"Nothing else will realistically work."

Celebrating a new Sloan School classroom from Goodyear. *When the time came for the Sloan School to move into three new classrooms in the M.I.T. building at 70 Memorial Drive last fall, Peter P. Gil (left), associate dean, and William F. Pounds, dean, joined two alumni who now head the company which helped make it happen to pose for this picture. The guests were John H. Gerstenmaier, S.M.'52 (center left), Goodyear's vice chairman and chief operating officer, and Joseph F. Hutchinson, S.M.'50 (far right), vice president. (Photo: Calvin Campbell)*

productivity improvements, management and career development, and organization diagnosis. . . . **Abhay Bhushan,** S.M. '71, reports that he has returned from a very successful year of social service in India doing village development. He has been promoted to manager, communications strategy analysis at Xerox Crop. upon return from his social service leave.

Warren S. Hoffman, S.M. '63, has been named senior systems consultant of Du Pont's information systems department. . . . **Richard A. Baehr,** S.M. '75, was promoted to senior vice president of Amherst Associates and moved to Atlanta in 1978 to manage the Southeastern area for his firm. **Giyora Doeh,** S.M. '58, reports, "Have made the break with West Coast aerospace industry by buying a Century 21 franchise. Am now a real estate broker and practical entrepreneur."

Leslie Clift Hruby, S.M. '73, has been promoted to large system product marketing manager at Digital Equipment Corp. She is responsible for the administrative and support functions for all of the large systems group. . . . **Robert B. Johnson,** S.M. '59, has been appointed a corporate vice president by the Board of Directors of Itek Corp. . . . **Philip A. Stevens,** S.M. '58, is currently vice president administration of the National Machinery Co., Tiffin, Ohio.

Robert B. Johnson

D. Tso, S.M. '74, was recently transferred from senior advisor planning to director crude supply, trading and transportation function, Gulf Oil Corp., Pittsburgh, Pa. . . . **Richard E. Wilson,** S.M. '73, reports that he is now executive vice president of Wallace O'Connor International Ltd. in Cairo, Egypt. . . . **James E. Soos,** S.M. '75, has been appointed a member of the Federal Senior Executive Service and has assumed the position of director for the Center for Communications Systems, U.S. Army Communications Research and Development Command, Fort Monmouth, N.J. . . . **Laurence S. Liebson,** S.M. '79, is president of the Prime Development Corp., Sacramento, Calif.

Rita A. O'Brien, S.M. '77, recently assumed the position of assistant vice president of New England Telephone Co. . . . **Brian P. Quinn,** S.M. '75, is president of Aeronautical Research Associates, Princeton, N.J.

Embrace Oil Profits, Don't Tax Them, says Forrester

The way to solve the nation's energy problem is to attract into the energy industries the nation's best minds — the most innovative engineers, the best strategists, the top managers.

An excess profits tax on American oil companies won't do that; indeed, it will "continue to repel financial resources and managerial skills from the energy field and thereby prolong our wandering in the energy wilderness," Jay W. Forrester, S.M. '45, Germeshausen Professor at M.I.T., told the Senate Finance Committee's Subcommittee on Energy and Foundations early this summer.

Professor Forrester's "world model," demonstrating by computer-based simulations that continued worldwide growth in population and consumption, won wide attention a decade ago; since then he and his Sloan School colleagues have been engaged in developing a detailed model of the U.S. economy.

His key argument for the Senate was that the nation needs "more risk capital and more investment in energy." Higher oil company profits would provide incentive for these, but the Carter administration's proposed excess profits tax would "substantially undo" those incentives. Indeed, it would instead "say that any person or institution that succeeds in energy wil be penalized." And it would "foster inefficiency" in the oil companies: "rather than show profits that will then be taxed, strong incentives will exist to increase costs to use up the profits," Professor Forrester said.

"If we want a long-term solution, we must accept some short-term disadvantages."

William F. Pounds Will Step Down; M.I.T.'s Senior Dean

William F. Pounds, who's been dean of the Sloan School of Management for almost 14 years, will leave that job at the end of the current academic year.

He wants "to explore some new areas and activities where I have much interest," he says; "the prospect of working toward a new set of commitments is very attractive." And Dean Pounds thinks it's a good time for the Sloan School to have new leadership, too. "Our faculty, administration, and programs are strong," he said when he announced his plans; he thinks "the process of selecting and attracting a new dean will be constructive for both M.I.T. and the school," and he thinks there will be an advantage to having a new dean join a new M.I.T. administration as it takes office.

By any standard, Dean Pounds' administration of the Sloan School will be recorded as a successful one; enrollment and programs have both grown and broadened, demand for admission is very high, as is demand for the school's graduates; and national studies without exception list the school among the best in the U.S.

Dean Pounds came to M.I.T. in 1961, two years after receiving his master's degree in mathematical economics at Carnegie Mellon University. He completed his Ph.D. for Carnegie Mellon in 1964 and became dean in 1966, when Howard W. Johnson, now chairman of the Corporation, was appointed president of M.I.T. Dean Pounds' undergraduate work at Carnegie Mellon was in chemical engineering (B.S., 1950).

Stimulating Agribusiness as the Missing Link in Industrial Development

U.S. companies operating in developing countries are too often cases of western affluence surrounded by poverty, a circumstance which inevitably breeds distrust, even hate, of the visitors.

In such a situation, every American, every time he turns around, sees a way to help his hosts improve t eir efficiency and productivity — and so move themselves closer to the goal of industrial prosperity. But it's almost never as simple as that: time and money are short, and Americans' involvement is often politically unacceptable.

But to **Robert H. Cotton,** S.M. '39, who entered the I.T.T. empire through Continental Baking Co. in the 1960s, came an unusual opportunity in 1974 to fulfill what must be every Americans' instinct to help those around him who are less fortunate than he. It was in that year that International Telephone and Telegraph, Inc., and the present government of Chile devised an unusual formula for repaying I.T.T.'s assets in the Chilean Telephone Co., expropriated by the previous Chilean regime: Chile and I.T.T. would join in establishing Fundacion Chile — an agency to advance industrial development in Chile through research, development, education, and training. To Mr. Cotton fell the job of running it, using funds provided by Chile (and matched by I.T.T.) as repayment of part of its debt — a total of $25 million (U.S.) in ten years.

Studying his options, Dr. Cotton concluded that food was a critical issue: "lack of sufficient, good food for a country's people is a major constraint to development," he writes. Too often, planners grow food for export to improve balance-of-payment positions instead of for consumption by the people who need it; sometimes land sits idle simply because nobody realizes how much good could come from its cultivation. And too much food is lost to inefficient processing and distribution.

No individual farmer can do much about problems like these. They belong to planners and managers in the agricultural sector — in a word, to agribusiness. And that's the missing element in many developing countries, says Dr. Cotton. So fostering this agribusiness concept became a keystone of Fundacion Chile's program. Some examples of the results:

☐ Fundacion Chile has marshalled Chilean and foreign experts to help local fishermen bring in saury, a slender-nosed fish which they regarded as trash — but for which there is in fact a lively export market.

☐ Fundacion Chile is helping develop handling and transportation facilities so that the plentiful fish catches landed in southern Chile can be brought to the northern interior areas where food is short.

☐ Seeking to achieve better teamwork among local industry, universities, and governments, Fundacion Chile is stimulating research and training in food preservation. Even in hungry nations, food is wasted because it can't be preserved fast enough at harvest time, says Dr. Cotton.

☐ In Chile's arid north there is almost no agriculture at all. But the sea is nearby, and several alternatives for food production in this area can be visualized: aquaculture, desalination and irrigation, and the use of salt-resistant crop varieties. Fundacion Chile is studying the possibilities.

While all this is going on, Dr. Cotton has returned from Chile to assume the post of chief scientist for I.T.T. Food Products. But the concept of this kind of help for developing countries — so that they can better help themselves — is still very close to heart, and he's working now as an adviser in the creation of a Foundation for International Technical Cooperation (F.I.T.C.).

His plan is that U.S. companies would loan their specialists to F.I.T.C. and — as a group — provide its funds. Then when opportunities appear to develop local agricultural resources in developing countries, talents and funds would be available. From F.I.T.C., thinks Dr. Cotton, should be spawned a series of foundations like Chile's — a whole new source of leverage for countries which lack agribusiness resources.

G. N. Wogan

Scrimshaw Steps Down as a Toxicologist Leads Food Science

Professor Gerald N. Wogan, whose field of toxicology is rapidly coming into prominence both at M.I.T. and in the nation, has been named head of the Department of Nutrition and Food Science. He succeeds Dr. Nevin S. Scrimshaw, Institute Professor, an internationally known figure in world food, nutrition, and health problems.

Dr. Scrimshaw has led the department to prominence in food science and technology since 1961; he will maintain an active role in teaching and research, and he will continue his work as director of its International Nutrition Program.

Professor Wogan came to recent prominence for studies of mold-produced toxins, naturally occurring carcinogens, and chemical carcinogenesis in foods. He now heads a new M.I.T. Center for Health Effects of Fossil Fuels Utilization, a cooperative effort of the Department of Nutrition and Food Science and the Energy Laboratory.

He studied biology at Juniata College, Huntingdon, Penn., and holds graduate degrees (M.S. 1953, Ph.D. 1957) in physiology, biochemistry, and microbiology from the University of Illinois. Dr. Wogan first came to M.I.T. as senior research associate in 1961 from Rutgers University, where he was assistant professor of animal physiology.

During November and December, in conjunction with the M.I.T. Office of Admissions and the Educational Council, AMITA conducted a series of alumnae visits to secondary schools in the Boston suburban area. The program, originally conceived by AMITA representatives three years ago, was designed to foster interaction between young women in high school and M.I.T.-educated alumnae currently working in technical occupations.

Approximately half of the 36 schools invited participated in the initial program (a high percentage, according to Admissions Office experience). During each visit, teams of alumnae discussed and promoted the value of pursuing science-oriented studies by young women, the importance of preparation necessary for admission to institutions such as M.I.T., and the many career opportunities available to women with strong science backgrounds.

Seventy alumnae participated, and with an additional support staff of 25 alumni and Institute members, provided a visible, experienced and well-coordinated presentation for the students. The student groups ranged in size from seven to 250, with the average being 20 to 50; the visiting alumnae were, in almost all cases, very enthusiastic about their experiences, finding the presentations well received and with many questions raised — ranging from technical admissions criteria to current women's issues.

Another program is planned for next year. It will serve not only as a follow-up session to this recent activity, but also might be structured to encourage greater involvement with parents.

The Trailblazers Program, a career workshop series for undergraduates sponsored by the Alumni Association, was held December 1. Participating, among others, were Liz Drake, Lita Nelson, Lois Champy, and Cynthia Helsel. In other related activities, the Committee to Strengthen Alumni Interactions with the Institute (now renamed Alumni Relations Committee) is establishing departmental liaisons and is offering I.A.P. programs related to professional disciplines. Jennifer Logan, Ph.D. '75, is participating this year. For the fifth year, AMITA offered its I.A.P. program of guidance for women in business and industry, including resume preparation, interview techniques, how to select among jobs and companies, and tricks for professional advancement. Chris Jansen and Lita Nelson continue to be instructors of this successful offering. — *Dianne Germany.*

MITR: After 20 Years a New Life for a Major Scientific Resource

On the 20th anniversary of its first start-up in 1958, the M.I.T. Research Reactor — so completely re-engineered that it is now called MITR–II — has earned a permanent place among the nation's major scientific resources of the current era.

Perhaps the most telling evidence of that fact was brought to a 20th-anniversary celebration last fall by Walter A. Rosenblith, Provost of M.I.T.: more than 1,000 articles and papers in the technical literature can be traced to research at the reactor, he said; of 1,400 papers listed through 1970 by the American Nuclear Society, 174 were from M.I.T.

The redesign of the reactor, completed just two years ago, has turned it into "a fundamentally different research tool," said Paul E. Gray, '54, Chancellor, at the ceremony. There is three times as much neutron beam flux as before; and the quality of that flux has been greatly increased at low energies and in the special medical facility associated with the reactor.

The total renovation cost was $3 million — "roughly half of the total money which the U.S. has spent on research reactor improvement during the past five years," according to Dr. Gray. "I know of no more dramatic illustration of a private institution acting in the national interest," he said.

Upon completion of the renovations, the Nuclear Reactor Laboratory was constituted a separate, free-standing interdisciplinary research center in order to emphasize its wide usefulness in many scientific fields. Since then the volume of research has grown from $900,000 to an estimated $2.2 million in the current fiscal year, and Professor Otto K. Harling, Director of the Laboratory, is confident that "the present trend of increasing and broadening" the use of MITR–II will continue.

Ford International Professor

Jagdish N. Bhagwati, Ph.D. '57, who returned to M.I.T. ten years ago to be Professor of Economics, is now Ford International Professor of Economics, an honor which recognizes his distinguished teaching and research in the field of international trade and development.

Professor Bhagwati, a native of India, taught at the Indian Statistical Institute and Delhi University between 1962 and 1967; he then returned to the U.S. for a one-year appointment at Columbia University before coming to the Institute. His research has led to several books and many papers in the theory of international development; he is Editor of the *Journal of International Economics;* and he holds the 1974 Mahalanobis Memorial Medal of the Indian Econometric Society.

Puzzle Corner
Allan J. Gottlieb

Cracking the Secret of the Baltimore Hilton

Allan Gottlieb is associate professor of mathematics and coordinator for computer mathematics at York College of the City University of New York; he studied mathematics at M.I.T. and Brandeis. Send problems, solutions, and comments to him at the Department of Mathematics, York College, Jamaica, N.Y., 11451.

I learned with interest from H. Spacil that "Puzzle Corner" has been well received by Nobuyuki Yoshigahara, a Japanese author of mathematical puzzles, and Dr. Spacil was good enough to send one of Mr. Yoshigahara's articles in Japanese. *Technology Review*'s printer occasionally finds "Puzzle Corner" difficult to typeset, but it's really a piece of cake compared to Mr. Yoshigahara's article. The Roman character set is, of course, much simpler than the Japanese. Incidentally, when American computer scientists returned from a stay in (mainland) China, they commented on how hard it is to computerize the Chinese character set.

Problems

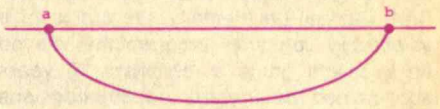
NS 18 (nee **1978 M/A 4**) We begin with a past problem that was **N**ever (completely) **S**olved:
A solitaire game (called accordian, among other names) consists of dealing a deck, one card at a time, and then examining sets of four cards. If the four cards are of the same suit, the middle two are discarded. If the four cards are of the same value, all four are discarded. What are the odds of winning (no cards left)? What if the whole deck is laid out before starting?

FEB 1 Our first new problem is a double chess challenge from Jerome Taylor:
White sets up pieces in standard form to start a game and has first move. Black sets his king in normal position; he may set what other pieces he uses on any unoccupied squares. For Black to have a forced win,
1. What is the least number of pieces that Black needs, what are they, and where are they placed?
2. If Black is restricted to pawns only, what is the least number needed, and where placed?

FEB 2 Our second problem is from the late R. Robinson Rowe:
Up on my carport roof one day, a rope I had laid down carelessly, with part hanging over the edge, began to creep. As I reached for it the creep became a gallop, and it all slithered off and down to the driveway. This suggested a hypothetical problem: suppose the roof was horizontal and perfectly smooth, the rope a slippery, flexible, homogeneous line mass five meters long overhanging one centimeter, and the edge mechanically equivalent to a frictionless sheave of infinitesimal radius, how long would it take the rope to slither off the roof?

FEB 3 Steve Gersuk wants us to help him break into the Baltimore Hilton. He writes:
On a recent business trip, I had occasion to stay at the Hilton Inn in Baltimore. In lieu of a conventional key lock, each room was equipped with a cipher lock that responded only to the four-digit code selected by the visitor when registering. In the course of playing with the lock (irresistable), I noted that the lock would open (indicated by a green LED) whenever the correct code was the last four digits of any sequence. In other words, any amount of garbage could be keyed in; if the last four digits matched, the bolt was energized. It occurred to me that the enterprising burglar would need to try many fewer than the 10,000 possible combinations if he could define a digit stream with the characteristic that each new digit entered resulted in a new four-digit sequence. The minimum number of entries must be 1,003 — four digits to enter the first number, with each of the subsequent 999 resulting in a new sequence. I see no obvious way to generate the most efficient sequence to minimize the number of keystrokes required. But surely this is child's play to *Technology Review* readers.

FEB 4 David Gluss needs help to plan a 500-mile trip; as you'll see, he doesn't want to dig too deep a tunnel. Mr. Gluss writes:



It is known that the fastest way to get an object from point a to point b in a uniform gravity field is a cycloid. If a and b are 500 miles apart, the maximum depth of the cycloid would be 159 miles. What is the fastest curve if there is a more severe depth limitation — e.g., 50 miles?

FEB 5 William Buttler has a warm-up for tax time. He notes that "the prospect of filling out 1040 forms and schedules, with their innumerable entries, can boggle the unprepared mind—unless one practices by working on a preliminary, less confusing task." He admits that the following problem is not as complex as our federal tax forms, but he hopes it will "help as an elementary warm-up exercise for stimulating our thinking caps": Five people had consecutive appointments with an income tax expert to help them fill out their 1040 forms and schedules. The electrical engineer had income from a savings account. The man who had a profit trading commodities was taking educational expenses as a deduction. When the man who contributed to a charity was leaving he met the taxpayer with dividend income. The biochemist is deducting interest on a mortgage. The computer programmer uses an SC-40 calculator. The man with three dependents is claiming storm damage as a deduction. The man with the charitable deduction followed the physicist. The man with five dependents exchanged amenities with the owner of the SR-50. When he looked at the tax expert's calendar, the man with the MX-140 noticed his name was next to that of the man with three dependents. The man with seven dependents sold some real estate for profit. The mathematician has six dependents. The income tax expert still had more than

one scheduled appointment after he met the man with dividend income. Each man had a profession, owned a calculator, had a deductible expense, had some number of dependents, and had a second source of income. Who won money in a contest? Who owned an HP-45 calculator? (Note: the problem has a unique solution against 24,883,199,999 erroneous combinations.)

Solutions

NS 16 A palindrome is a number that reads the same left to right and right to left — e.g., 18781 and 372273. Take an arbitrary number and add it to its mirror image. If the sum is not a palindrome, add it to its mirror image. Keep going. Will a palindrome necessarily result? (It is reported that 196 is a particularly interesting one to try because it never yields a palindrome, but proof is lacking.)

Although we still have no proofs, several "experimental" results have been reported. Kathryn Bittman, E. Phillips, and Arthur Samuel have worked on the 196 sequence. Prof. Samuel (incidentally, the author of a celebrated computer program that played an excellent game of checkers 20 years ago) carried the analysis to 2,392 additions and 1,000 digits. Mr. Phillips supplied a lengthy argument to show that it is unlikely for a sequence to terminate after a large number of terms. A copy of the results of Phillips and Samuel can be obtained from the editor. Here I will reprint their summaries only. Mr. Phillips' results (all occurrence frequencies are relative to the universe of 900 three-digit starting points):

Number of digits in palindrome	Typical starting point	Occurrence frequency (per cent)
5	176 (or 79)	11.6
6	188	2.8
7	589	0.4
8	167	1.0
10	177	1.2
12	998	0.2
13	187 (or 89)	1.0
No palindrome?	196	1.4
Total over 4		19.7

Prof. Samuel's results:
Palindromes, when formed, seem to occur with a reasonably small number of additions. The number of different classes as well as the percentage of intransigency (numbers not forming palindromes within the calculations performed) seems to go up rapidly with the number of digits in the original numbers. The fact that intransigent cases exist with additions carried to 100 digits is no proof that some of these cases might not lead to palindromes if the search were extended. There are gaps in the tables; for example, no palindromes were found for three-digit numbers requiring adds of 12, 13, 16, and from 18 to 21, and there could be a longer gap from 24 to 223. This does seem unlikely, but we have no proof. I did carry the analysis for 196 to 2,392 additions and 1,000 digits, but even this is no proof. Results to 169 additions and 75 digits are attached.

I extended the analysis to six-digit numbers. About the only significant fact that seems to emerge is that the required number of adds seems to be going up:

Number of digits	2	3	4	5	6
Intransigent classes	0	3	11	246	937
Intransigent cases	0	13	233	5774	*
Palindrome classes	18	177	331	3174	5561
Palindrome cases	90	887	8767	84226	*
Maximum adds for P's	24	23	21	55	64

* Not computed, but the total would be 90,000.

OCT 1 Suppose you and dummy have two seven-card fits (i.e., suits in which you are lacking six cards). The *a priori* odds for the division of six outstanding cards are well known at 48:36:15:1 for a 4-2:3-3:5-1:6-0 split. My question is, How do those odds change for the division of the second suit after you have played the first suit and established what the first split was? In particular, what are the odds for the division(s) of the second suit when the first suit is known to have split (a) 4-2 or (b) 3-3?

The following solution is from Alan LaVergne:
There is a certain ambiguity in the statement of the problem. At least when the first suit splits unevenly, it matters how one finds out about it. The odds on the various divisions of the second suit will depend on whether (1) one is simply told about the 4-2 split, or (2) the 4-2 split is discovered by playing three rounds of the first suit. In case (1), the declarer will know two cards in one opponent's hand, and four cards in the other's. In case (2), the declarer will know three cards in one hand and four in the other. Rather than trying to divine the proposer's intention, I will calculate the odds in case (1) and in case (2), given that the discard was not a card in the second suit. If there are N unknown cards in one opponent's hand and M in the other's, and $\min(M,N) \geq \max(A,B)$, the probability of an A-B division in a suit is

$$\frac{(A+B)!}{A!\,B!}\left[\frac{N!}{(N-A)!}\,\frac{M!}{(M-B)!}\,\frac{(N+M-A-B)!}{(N+M)!} + \frac{N!}{(N-B)!}\,\frac{M!}{(M-A)!}\,\frac{(N+M-A-B)!}{(N+M)!}\right]$$

unless A = B, when one of the terms in the sum is omitted.
If the first suit splits 3-3, then N = M = 10 in the above formula. If the first suit splits 4-2, then N = 11, M = 9 in case (1) above, and N = 10, M = 9 in case (2). The results for the 6-0, 5-1, 4-2, and 3-3 splits, respectively, are:
7:84:315:240 if the first suit splits 3-3,
91:924:3135:2310 if the first suit splits 4-2 (case 1),
7:84:315:240 if the first suit splits 4-2 (case 2),
12:117:390:286 if there is no information about any other suits.

In other words, the probabilities for the various divisions of the second suit are the same in these two situations: (I) Both opponents follow to three rounds of the first suit; (II) Both opponents follow to the first two rounds, but one opponent discards something from the third or fourth suit on the third round. I cannot explain why this should be so, but it is true in general: one gets the same results from the above formula by plugging in either N = M or N = M − 1. Summarizing the results:

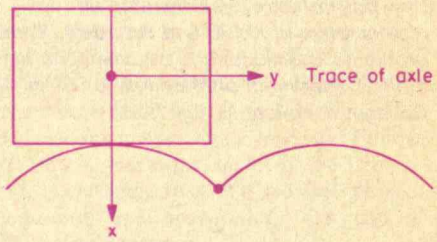
split	no information	3-3 or "4-3"	4-2
6-0	1.491%	1.084%	1.409%
5-1	14.534	13.003	14.303
4-2	48.447	48.762	48.529
3-3	35.528	37.152	35.759

Thus the 4-2 split in the first suit hardly changes the odds for the second suit at all, while the 3-3 and "4-3" splits slightly favor the flatter distributions in the second suit.

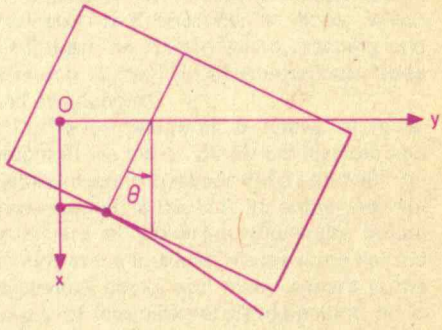
Also solved by Jerry Grossman.

OCT 2 Describe a track on which a square wheel rolls smoothly without slipping.

Ten years ago Edwin McMillan wrote a paper on all sorts of "funny" wheels: lines, squares, and inclined planes, for examples. A copy of this paper can be obtained from the editor. In this case, we have several "conventional" solutions and one elaborate photographic demonstration. The following is from Doug Szper:
Consider a square wheel with side of length 2 units. We are asked to describe the track upon which such a wheel can roll smoothly without slipping. It suffices to describe the section of track over which the wheel turns through an angle θ from 0 to $\pi/4$, since the rest follows by symmetry, where $\theta = 0$ corresponds to one side parallel to the ground.



Define a coordinate system with the Y-axis parallel to the ground, along the trace of the axle, and the X-axis increasing downward from the origin, at the axle position for $\theta = 0$. It is assumed that the axle is always directly above the point at which the wheel touches the track, as shown below.



Indicate the tangent point as $(x(\theta), y(\theta))$ in the coordinate plane. The distance along the track to $(x(\theta))$ is $\tan\theta$, since there is no slipping. Thus we have:

$$\int_0^{\theta}\left[\left(\frac{dx}{d\theta}\right)^2+\left(\frac{dy}{d\theta}\right)^2\right]^{\frac{1}{2}} d\theta = \tan\theta \qquad (1)$$

Since the axle moves along the line X = 0, the value $x(\theta)$ equals $1/\cos\theta$. Thus $dx/d\theta = \sin\theta/\cos^2\theta$. Differentiating formula (1) with respect to θ, we obtain:

$$\left[\left(\frac{dx}{d\theta}\right)^2+\left(\frac{dy}{d\theta}\right)^2\right]^{\frac{1}{2}} = \sec^2\theta \qquad (2)$$

Substituting $\sin\theta \cdot \sec^2\theta$ for $dx/d\theta$ and solving, we obtain:

$dy/d\theta = (\sec^4\theta - \sin^2\theta \sec^4\theta)^{\frac{1}{2}}$
$= \sec^2\theta \cdot \cos\theta = \sec\theta$

Thus we find:

$$y(\theta) = \int_0^{\theta} \sec\theta\, d\theta = \log(\sec\theta + \tan\theta)$$

The track segment is thus defined by the set of points:

$\{(x,y) = [\sec\theta, \log(\sec\theta + \tan\theta)]|$
$0 \le \theta \le \pi/4$

Or:

$y = \log(x + (x^2 - 1)^{\frac{1}{2}})$
for: $1 \le x \le \sqrt{2}$

Also solved by Harry Zaremba, Alan LaVergne, Raphael Justewicz, James Landau, Edmond Nadler and Allen Tracht.

OCT 3 Find the smallest number N which can be partitioned into seven distinct positive integers such that the sums of any six is a perfect square; then try for eight positive integers with the sum of any seven a square, then any eight out of nine, and finally any nine out of ten.

Harry Zaremba sent us a concise solution:

The smallest integers N, the partitioning, and the corresponding squares in each case are as follows:

Seven-integer partition:
N = 2,236.
Integers = 27, 120, 211, 300, 387, 555, and 636.
Squares = 40^2, 41^2, 43^2, 44^2, 45^2, 46^2, and 47^2.

Eight-integer partition:
N = 3,156.
Integers = 20, 131, 240, 347, 452, 555, 656, and 755.
Squares = 49^2, 50^2, 51^2, 52^2, 53^2, 54^2, 55^2, and 56^2.

Nine-integer partition:
N = 4,908.
Integers = 8, 147, 284, 419, 552, 683, 812, 939, and 1,064.
Squares = 62^2, 63^2, 64^2, 65^2, 66^2, 67^2, 68^2, 69^2, and 70^2.

Ten-integer partition:
N = 8,656
Integers = 7, 192, 375, 556, 735, 912, 1,087, 1,260, 1,600, and 1,932.
Squares = 82^2, 84^2, 86^2, 87^2, 88^2, 89^2, 90^2, 91^2, 92^2, and 93^2.

Also solved by Frank Rubin, Alan LaVergne, Neil Hopkins, L. Postas, and Al Weiss, who claims that I am "a capitalist tool in the employ of the computer manufacturers" because of the large quantities of machine time my problems require.

OCT 4 What are the dimensions of Smith's ranch, described in the following conversation?

SMITH: Down in Todd County, which is a 19-mile square, I have a ranch — rectangular, not square, in shape — measuring a whole number of miles each way.

JAMES: Hold on a minute. I happen to know the area of your ranch; let me see if I can figure out its dimensions. (He figures furiously.) I need more information. Is the width more than half the length?

Smith answered the question.

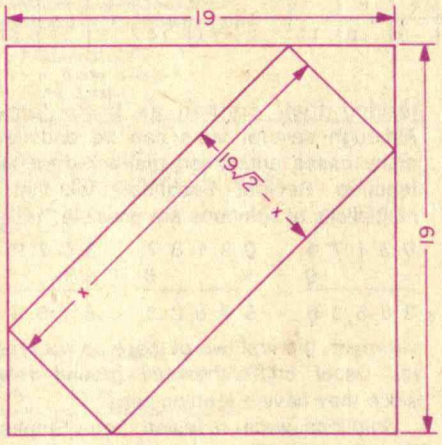
JAMES: Now I know the dimensions of your ranch.

BROWN: I, too, know the area and, although I did not hear your answer to James' question, I, too, can tell you the dimensions.

GREEN: I did not know the area of your ranch but, since I have heard this conversation, I can deduce it.

Harry Garber avoided the trap of assuming that all sides are limited to 19 miles. This trap caused several readers to go astray. Mr. Garber's solution follows:

One key to this problem is to realize that rectangles with length greater than 19 miles can still fit inside a 19-mile-by-19-mile square. For a rectangle with length x miles, the largest possible width is $19\sqrt{2} - x$ miles:

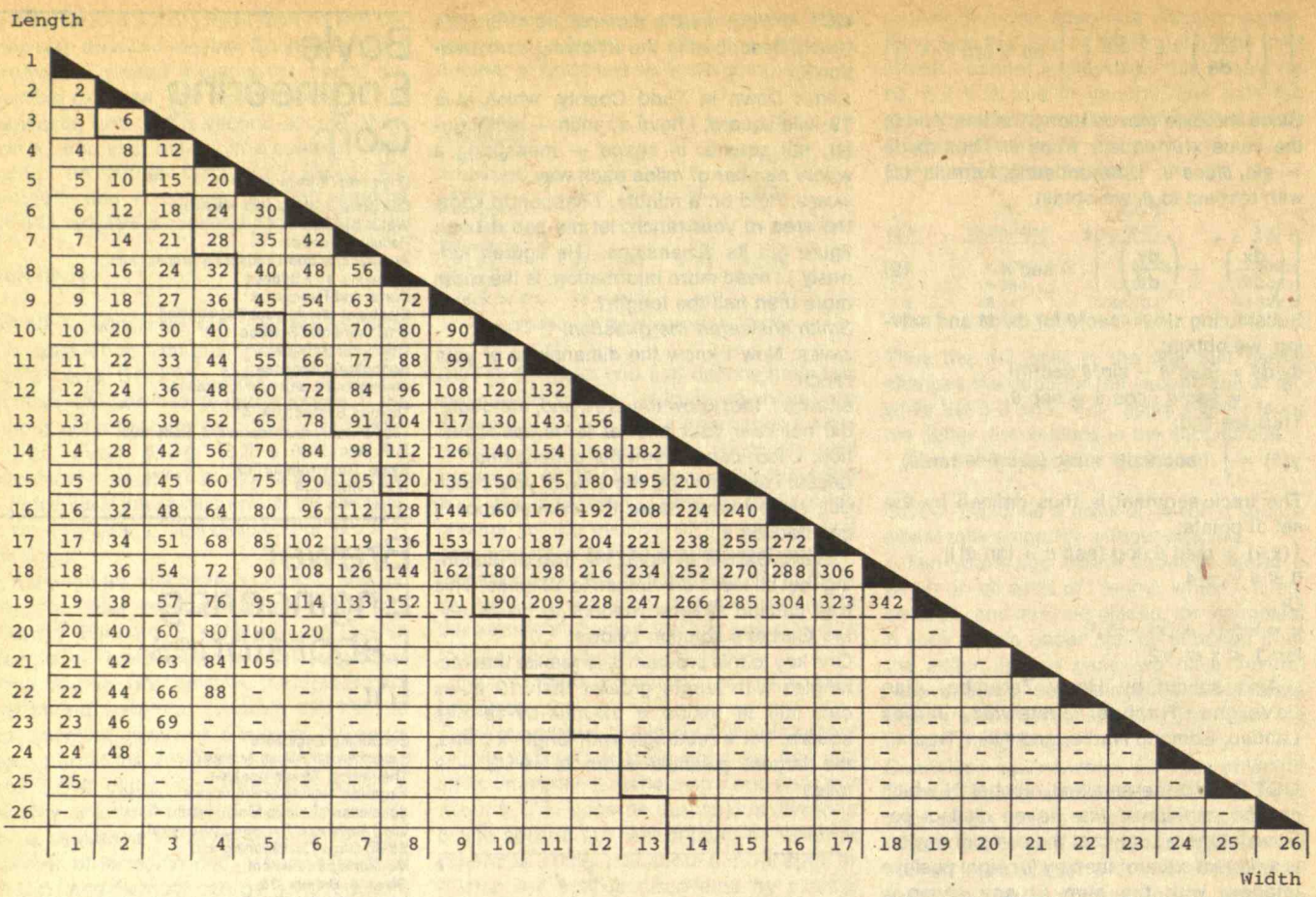


Recalling that we are dealing with only whole-number dimensions, I constructed a table containing the areas resulting from all possible pairs of dimensions, shown across the bottom of this page. The "staircase" is a boundary; all areas above it have width > length/2 while all areas below it have width ≦ length/2. I arranged the areas in ascending order, and after each value indicated how many times that value appeared above (Y) or below (N) the staircase. I won't bore you with my entire result, but a coded portion of my list looks like this:

2 N	6 NY	18 NNN	144 NY
3 N	7 N	24 NNNY	180 YY
4 N	8 NN	119 N	255 Y
5 N	12 NNY	120 NYY	342 Y

For example: an area of 24 square miles can result from four different pairs of dimensions, three below the staircase and one above the staircase.

Now we can deduce the area logically, as Green did. Since James required more information, we eliminate any value which occurs only once (e.g., 7, 119, or 255). Not



Length \ Width	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1																										
2	2																									
3	3	6																								
4	4	8	12																							
5	5	10	15	20																						
6	6	12	18	24	30																					
7	7	14	21	28	35	42																				
8	8	16	24	32	40	48	56																			
9	9	18	27	36	45	54	63	72																		
10	10	20	30	40	50	60	70	80	90																	
11	11	22	33	44	55	66	77	88	99	110																
12	12	24	36	48	60	72	84	96	108	120	132															
13	13	26	39	52	65	78	91	104	117	130	143	156														
14	14	28	42	56	70	84	98	112	126	140	154	168	182													
15	15	30	45	60	75	90	105	120	135	150	165	180	195	210												
16	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240											
17	17	34	51	68	85	102	119	136	153	170	187	204	221	238	255	272										
18	18	36	54	72	90	108	126	144	162	180	198	216	234	252	270	288	306									
19	19	38	57	76	95	114	133	152	171	190	209	228	247	266	285	304	323	342								
20	20	40	60	80	100	120	-	-	-	-	-	-	-	-	-	-	-	-	-							
21	21	42	63	84	105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
22	22	44	66	88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
23	23	46	69	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
24	24	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
25	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

knowing Smith's answer to James's question, Brown couldn't be so certain of the dimensions if the correct value were an NY entry, so we eliminate those (e.g., 6, 144). And James also couldn't be certain if the area involved all one letter such as NNN or YY, so we eliminate those (e.g., 8, 18, 180). This narrows the original list of 192 coded area values down to just thirteen values:

12 NNY	40 NNY	72 NNY	
20 NNY	42 NNY	80 NNY	
24 NNNY	48 NNNY	84 NNY	
30 NNY	60 NNNY	90 NNY	120 NYY

Now, Smith's answer to James's question couldn't allow Green to even be certain of the area, much less the dimensions, if that answer were Y. But there *is* one area where an N answer does uniquely determine the dimensions. That area is 120 square miles; hence the dimensions of the ranch are 20 miles by 6 miles.

Responses received from Jordan Wouk, Ronald Ort, L. Postas, Robert Zimmerman, Harry Zaremba, Alan LaVergne, Smith Turner, and P. Jung.

OCT 5 Replace each letter with a unique digit:

FOUND × A = SKILL

What is the value of SKILL? This is the *only* short multiplication in base 10 which has a unique solution and which involves as few as eleven digits in total. That is, this is the best possible problem, in the sense of least redundancy.

Many readers used a computer search for this problem. Those who did not characterized their method as brute force. Although several facts can be deduced, many cases and much trial-and-error are required. Several responders felt that a multiplicity of solutions are possible:

0 3 1 7 4	0 9 1 3 7	3 0 7 9 4
× 9	× 6	× 2
2 8 5 6 6	5 4 8 2 2	6 1 5 8 8

However, the first two of these do not meet the usual criptarithemetic ground rules since they have a leading zero.

Solutions were received from Stephen Washburne, Robert Zimmerman (from Guadalajara), Harry Garber, G. Ropes, James Landau, Harry Hazard, Ronald Ort, Peter Sorant (a Baker House colleague of mine), Harry Zaremba, Alan LaVergne, Avi Ornstein, and Naomi Markovitz.

Better Late Than Never

J/J 2 Neil Hopkins has submitted the following comments:

I was one of the original solvers of this problem, and I believe that Mr. Furthmyer's concern warrants a reply. I'm happy to oblige.

1. One has to proceed with the assumption that there is a solution to the problem. Frank Rubin is an honorable man.

2. We are asked to find the length of the bridge. Nothing else. Six equations and six unknowns provide two solutions. One solution results in a good round number to the length of the bridge, strongly suggesting that this is the solution the author had in mind. Consequently I submitted the following: "The bridge is ten miles long, and the foot-traveller establishes new records for walking and running speeds."

3. Information regarding the passage of the diesel obviously involves only the length of the diesel, not a solution requirement. It cannot alter the results already obtained under (2) above. It cannot add new sets of values. It cannot eliminate both solutions based on the original premise per (1) above. It can eliminate one of the two solutions; that is all. I paid no attention to this distraction, confident that I had arrived at the solution the author had in mind — correctly, it seems. In the real world, the engineer involved with railroad bridges takes nothing for granted. He has to be on guard against venality, rascality, and stupidity. He must check everything, including the length of the diesel. In the happy never-never land of Aardvark and Zymurgy, where railroad bridges are ten miles long and a foot traveller skips along at record-breaking speeds, we get into the spirit of the place and ignore such niceties as the speed of sound in air, starting and stopping velocities of trains, and the like. I had no difficulty with this aspect of the problem.

Y1979 and **PERM 3** John Gratwick and George Gerling have responded, and the latter also found an interesting "solution" to the John Rule challenge. Mr. Gerling writes:

While solving **Y1979** I became curious as to whether any four-digit combination produced all of the first 100 integers. Under the rules, there is none. The most prodigious are 1,389, 2,347, and 2,379, each of which

generates 98 integers, and 1,379, 2,356, and 2,457, which generate 97. Fourteen combinations generate 96 integers, and eight more produce 96. The digit combinations which produce the most successive integers are 1,278 (all integers through 92 and a total of 96) and 2,367 (all through 90 and a total of 96). You mentioned curiosity about how 1,999 and 2,222 will fare. The sequence 1,999 generates only 32 integers, failing first on the integer "4." The sequence 2,222 produces 27 integers failing first on "7." My investigation of all the possible four-digit combinations suggested that if the field of search could be increased by an order of magnitude, some combinations producing 99 integers would be found and, with a little luck, there would be one or two that produced all 100. (There appears to be considerable independence between the integers that are generated by using four digits and three operators and those generated by juxtaposition of digits and fewer operators). I increased the field of search by allowing the additional assumption that the digits can be assumed to be in any given base in which they have validity (i.e., use of digits 0-7 in base 8 and use of all 10 in any base larger than 9). The results were quite interesting. I found many sequence-base combinations which yielded 99 integers but only one that produced all 100. It is the digit combination 2,345, in the base 19. A selection of optimal solutions is shown on the next page (optimized for a number of operators but with no preferential digit sequence). This sequence is also interesting in that it produces only the first 100 integers and does not generate either "101" or "102." I have ceased work on a rather inelegant proof that this is the only such sequence that exists, but I would be surprised if a second example (or more) were found. Perhaps your readers would enjoy the challenge of finding this unique solution under the expanded condition of permitting bases other than 10 to be assumed. Needless to say, my work was computer-aided.

FEB 4 Smith Turner defended and explained his solution: "The E refers to the EE key on the SR-50. The integers produced after EE are displayed at the right, and — so help me — you will find $3^2 = 7$. Ha!"

MAY 4 Richard Askey notes that relevant work in this area was done by Gauss in the last century and by Jim Wilson last year.

A/S 1 P. Jung, Michael Kay, and Winthrop Leeds responded. Frank Rubin feels that Black, by moving K—QN8 and R—QN7, can draw against White's queen and king. However, I believe that White can win that position and that the computer program BELLE proved this.

OCT SD 1 G. Michael, R. Cralle, and a CDC-7600 found the following solutions: bilihumin, dislikelihood, Elihu, goodlihead, kinglihood, knightlihood, Lihyonite, likelihead, likelihood, livelihood, lonelihood,

Y 2345 (Base 19)

The following are optimal solutions for minimal number of operators, but with no preference given to digit sequence, & the equivalent expression in base 10.

	Base 19	Base 10		Base 19	Base 10
1.	(3-2)**45	(3-2)**81	51.	34-(2*5)	61-(2*5)
2.	5+3-4-2	same	52.	((2**3)+5)*4	same
3.	(2*5)-4-3	same	53.	(53/2)+4	(98/2)+4
4.	4-2-3+5	same	54.	(45/3)*2	(81/3)*2
5.	(2+3-4)*5	same	55.	25+(4*3)	43+(4*3)
6.	2+3+5-4	same	56.	53-24	98-42
7.	(3*5)-(2*4)	same	57.	24+(3*5)	42+(3*5)
8.	2+4+5-3	same	58.	54-23	99-41
9.	45/(2**3)	81/(2**3)	59.	32*(5-4)	59*(5-4)
10.	(25-3)/4	(43-3)/4	60.	35+2-4	62+2-4
11.	54/(3**2)	99/(3**2)	61.	23+(4*5)	41+(4*5)
12.	(5*4)-(2**3)	same	62.	2+(3*4*5)	same
13.	(25-4)/3	(43-4)/3	63.	42-(3*5)	78-(3*5)
14.	2+3+4+5	same	64.	34+5-2	61+5-2
15.	(35-2)/4	(62-2)/4	65.	((3**2)+4)*5	same
16.	42-35	78-62	66.	(54/3)*2	(99/3)*2
17.	(2**3)+4+5	same	67.	(4**3)+5-2	same
18.	34-25	61-43	68.	34+5+2	61+5+2
19.	(24/3)+5	(42/3)+5	69.	43-(5*2)	79-(5*2)
20.	35-24	62-42	70.	35+(2*4)	62+(2*4)
21.	(42/3)-5	(78/3)-5	71.	34+(2*5)	61+(2*5)
22.	45-32	81-59	72.	45-(3**2)	81-(3**2)
23.	(2+4)*3+5	same	73.	45-(2**3)	81-(2**3)
24.	(53-2)/4	(98-2)/4	74.	(3**4)-2-5	same
25.	(53+2)/4	(98+2)/4	75.	45-(2*3)	81-(2*3)
26.	((2*3)*5)-4	same	76.	45-2-3	81-2-3
27.	(35/2)-4	(62/2)-4	77.	((2**4)*5)-3	same
28.	(34-5)/2	(61-5)/2	78.	(2**4)+35	(2**4)+62
29.	34-(2**5)	61-(2**5)	79.	32+(4*5)	59+(4*5)
30.	(3*4*5)/2	same	80.	45+2-3	81+2-3
31.	35/(4-2)	62/(4-2)	81.	45*(3-2)	81*(3-2)
32.	23-4-5	41-4-5	82.	45-2+3	81-2+3
33.	(34+5)/2	(61+5)/2	83.	(5**3)-24	(5**3)-42
34.	24-5-3	42-5-3	84.	24*(5-3)	42*(5-3)
35.	(35/2)+4	(62/2)+4	85.	52-(3*4)	97-(3*4)
36.	43-25	79-43	86.	2+3+45	2+3+81
37.	(43-5)/2	(79-5)/2	87.	(2*3)+45	(2*3)+81
38.	(3**4)-25	(3**4)-43	88.	((5**2)-3)*4	same
39.	32-(4*5)	59-(4*5)	89.	(2**3)+45	(2**3)+81
40.	45-23	81-41	90.	45+(3**2)	81+(3**2)
41.	23*(5-4)	41*(5-4)	91.	54-(2**3)	99-(2**3)
42.	23-4+5	41-4+5	92.	53-2-4	98-2-4
43.	25*(4-3)	43*(4-3)	93.	54-(3*2)	99-(3*2)
44.	24+5-3	42+5-3	94.	54-3-2	99-3-2
45.	(53/2)-4	(98/2)-4	95.	((2**4)+3)*5	same
46.	35-(2**4)	62-(2**4)	96.	53+2-4	98+2-4
47.	43-(2**5)	79-(2**5)	97.	52*(4-3)	97*(4-3)
48.	(54-3)/2	(99-3)/2	98.	54-3+2	99-3+2
49.	53/(4-2)	98/(4-2)	99.	54*(3-2)	99*(3-2)
50.	23+4+5	41+4+5	100.	54-2+3	99-2+3

lovelihead, manlihood, millihenry, seemlihead, selihoth, superlikelihood, and unlikelihood.

OCT SD 2 David Kaufman and Joseph Friedman note that $a = 3(\sqrt{2} - 1)$. This is the same as $3/(1 + \sqrt{2})$.

Responses have been received as indicated:
J/J 1 Peter Sorant and (Ms.) Ronnie Rybstein.
A/S 3 James Landau, Naomi Markovitz, Frank Rubin, and Harry Hazard.
A/S 4 P. Jung.

Alumni Association

Massachusetts Institute of Technology

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How Much Does It Cost?

The major impetus for the conversion to EFT systems was the potential for reducing costs below those of conventional check processing. So far, this hasn't happened. To provide EFT service, a bank must make a large capital investment for installing the components of the system — hardware, software, telephone lines, and support systems. This investment is, of course, in addition to the large investment already made in traditional check-processing equipment and does not include yearly maintenance costs, which can be as much as 25 per cent of original costs.

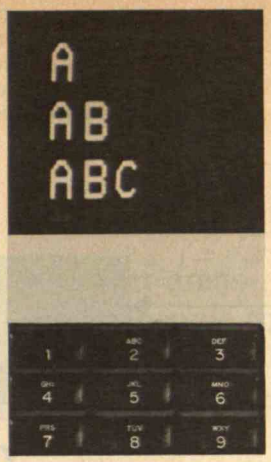
John Benton, executive director of the National Commission on Electronic Fund Transfers (NCEFT), says that to set up a partial-service EFT check verification system with 350 terminals in a major metropolitan city, a bank would have to invest an initial $1.5 million plus $350,000 each year for maintenance. To reduce costs per transaction to less than $.05, a figure quoted by some giant banks as their current share of check-processing costs per transaction, an EFT system must consist of 5,000 to 10,000 terminals each transmitting 2,500 to 5,000 transactions per month. Currently, large full-service systems cost an average of $0.45 per transaction.

EFT systems can proliferate only with large-scale acceptance and use, and the consumer is the key to both. For EFT to succeed, the consumer must really believe that he or she will benefit from the system and not that electronic funds transfer is just "technology looking for a market."

Consumer Benefits

An extensive EFT network will give the consumer many benefits. Probably the most important benefit to the consumer is that her money will be more accessible. No more will the consumer be frustrated by rigid banking hours; she will have access to her bank accounts twenty-four hours a day, seven days a week.

A related benefit is that ATMs, located in supermarkets, airports, and even on the exterior walls of



The Passwords to EFT

Access (or Debit) Card — a magnetically encoded plastic card that the customer uses to gain access to the terminal. Generally, the coding is the customer account number which, along with a password, assures that the person at the terminal is a bona fide customer.

Automated Clearinghouse (ACH) — the essential feature of the EFT system that handles recurring payments initiated in large volumes. Usually managed by the Federal Reserve, ACH transactions parallel check-cashing operations. The fundamental difference is that instructions to transfer funds are on magnetic tape and not on checks.

Automated Teller Machine (ATM) — a terminal that completes nearly all the transactions normally executed by a bank teller. Often referred to as "cash dispensing machines," ATMs are usually found in banks but are beginning to appear in supermarkets, airports, and other places with large numbers of potential customers. ATMs are activated by access cards.

Electronic Funds Transfer System (EFT or EFTS) — a network of banks, retail stores, and other financial institutions that transfers money electronically without the use of cash of checks. Limited EFT systems have existed for a decade.

Float — funds that have been credited to one account before they have been debited from another account. A customer depends on the float when he writes checks a few days before depositing his paycheck.

Pay-by-Phone — a bank service that allows the customer to call in instructions for the payment of recurring bills. This may include giving the instructions to an operator or directly to the computer by using the phone's touch-tone control to input the account number and amounts of the bills to be paid.

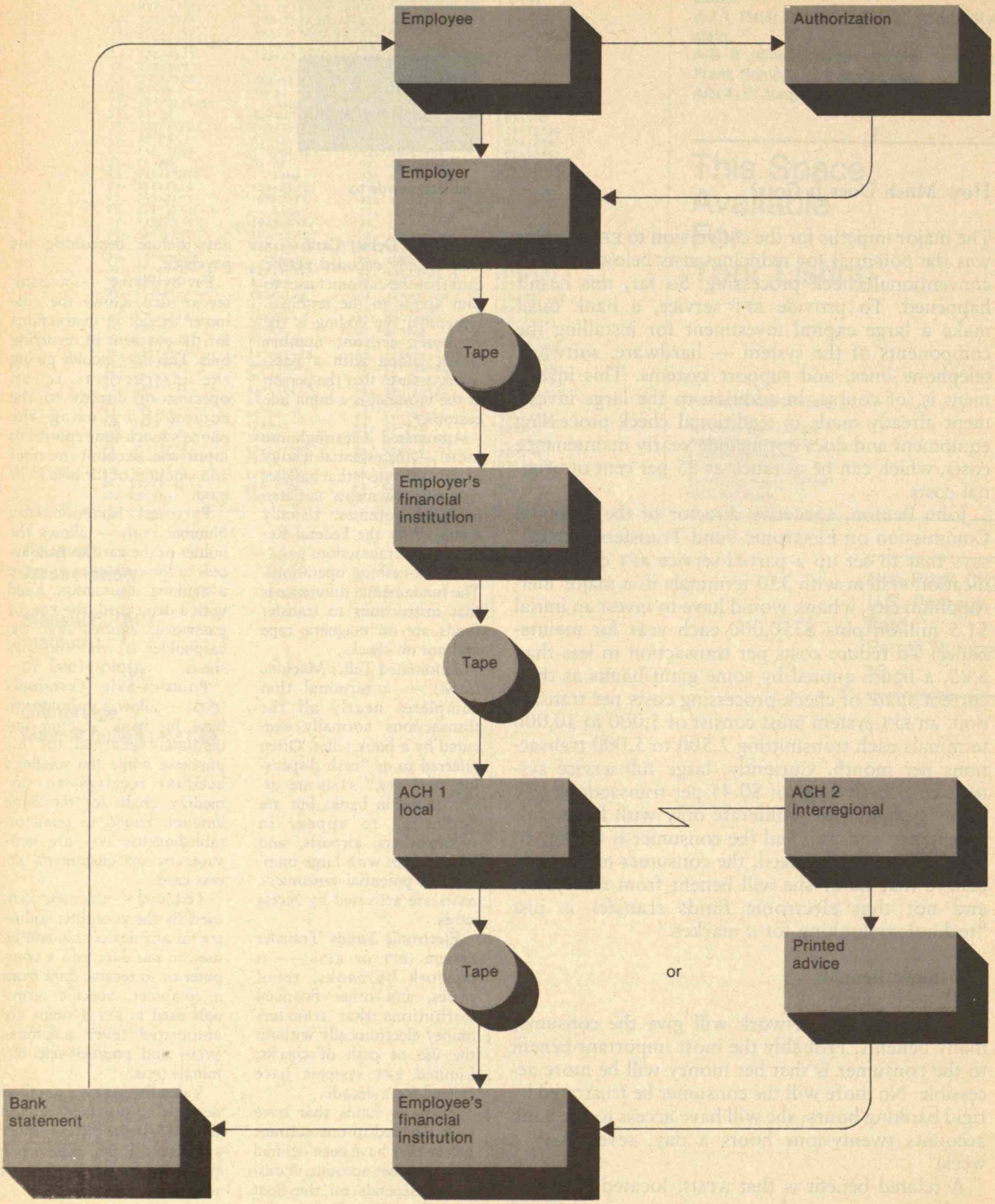
Personal Identification Number (PIN) — allows the holder of the card to gain access to the computer to make a banking transaction. Used with a debit card, the PIN, or password, assures that the cardholder is who she says she is.

Point-of-Sale Terminals (POS) — allow a customer to have his bank account immediately charged for his purchase while the retailer's account receives an immediate credit for the same amount. Found in retail establishments, POS are activated by the customer's access card.

Terminal — a generic term used by the computer industry for any device that can be used to put data into a computer or to receive data from a computer. Specific terminals used in EFT systems are automated teller machines (ATM) and point-of-sale terminals (POS).

Value-Dating — a method designed to provide a float in the EFT system. The consumer specifies a future time when the actual payment of funds will occur. □

Direct payroll deposit is one of the simplest of electronic funds transfers, but it still involves many steps, most of which are not readily apparent to the employee who signs a request to have her paycheck deposited directly in her bank account. *(Source: Federal Reserve Bulletin)*



Many banks in retirement areas
provide coffee and set aside an area for people to sit and talk.
Probably nothing
could make them give up these social occasions.

banks, are often more convenient than local branch banks. An NCEFT study found that 60 per cent of the population handle all their financial transactions by visits to financial institutions and that 55 per cent visit a depository institution at least once a week. Clearly, many people will benefit from more convenient locations.

With fewer checks and less cash used for financial transactions, security will improve. Criminals simply will have fewer opportunities to commit such offenses as robbery, forgery, larceny, and mail theft. If the poor and elderly are encouraged to use EFT for cash purchases, the number of robberies committed against this particularly vulnerable segment of the population might be reduced.

The rules established by ACH associations provide for two benefits not found in the standard check payment system. First, procedures for the resolution of errors provide for greater consumer protection than provided by the uniform commercial code for check payments. Also, transaction reversals, not provided by the traditional check system, are permitted with EFT.

EFT allows depository institutions to provide banking services not previously available. Traditionally, regulations designed to preserve a solvent and stable monetary environment have limited competition, but if EFT can help overcome legal constraints, then expanded consumer services will increase competition.

Finally, there is the potential customer benefit of cost reduction. If banks are able to realize savings through EFT — and it is reasonable to assume that with economies of scale some savings will occur — then some of these savings might be passed on. But the larger unanswered question is who will benefit most from EFT, banks or customers.

"You Can't Argue with a Computer"

Despite the benefits, however, certain issues keep the consumer from embracing EFT.

One important concern is the loss of human interaction and the prospect of a human vs. machine confrontation. Experience of banks in retirement areas has shown that retirees are not willing to accept automatic deposit of Social Security checks because it deprives them of the monthly visit to the bank. Many banks in retirement areas provide coffee, set aside an area for people to sit and talk, and some even give dog biscuits to retirees' pets. Probably nothing could make them give up these social occasions for automatic deposit of Social Security checks.

Anyone who has ever deposited money in a soda machine, only to find that it does not deliver the product, knows that we humans have difficulty dealing with nonworking machines. Upon receiving his bank statement, a friend noted a mysterious $50 charge. He drove to the bank where he confronted the manager with his problem. The manager told him that it was a "computer transaction." The friend knew he had not used the computer terminal for a transaction that particular day. Unfortunately, feeling intimidated, the fellow let it drop and later explained, "You can't argue with a computer."

But you can and should argue with computers. In this instance, both the bank employee and the customer were wrong. The customer should have insisted on a complete and satisfactory explanation and the bank employee should have offered to trace the transaction.

Crimes and Other Irregularities

Another major issue is concern over the security of EFT systems. Problems such as unauthorized use of debit cards, errors, and the assignment of liability as transactions move through the system have yet to be totally resolved. Unauthorized access to an EFT system gives a thief the ability to steal much more than the cash-on-hand taken in a conventional hold-up.

The customer, however, is not the only victim of problems with EFT. Sometimes the bank is the loser. A couple of years ago, several ATMs of the California-based Bank of America dispensed cash without recording the transactions. Several hundred transactions were processed before the bank caught the error. Even after they received their monthly statements, not one customer reported the error.

The Case of the Missing Password

No one is immune to the wrath of EFT machines — not even one of the authors.

Upon opening a checking account at a Massachusetts bank, I was issued a cardboard card that could be used to cash checks at other Massachusetts banks owned by the same holding company. A few weeks later, I moved over 50 miles away from the original bank but continued to cash checks at other banks with the card.

One day a plastic debit card arrived in the mail. The accompanying instructions said to destroy the cardboard card. The new card, they said, would do everything the other card did, and would also allow me to use the new automated teller machines being installed at all the banks. I wondered how I was to obtain a password, but realized that I would most likely get one on my next trip to the bank.

Several days later I went to a local bank to cash a check. The teller told me that the automated teller machine would have to verify my check first. The instructions on the machine said that I needed a password to operate it.

Back to the real teller.

She called over the branch manager. He tried to explain that the password, or personal information number, came with the card (which was not true). Finally, he must have assumed that the problem was beyond him and explained that I would have to clear up the problem with the branch that issued the card.

"Now, just give me the cardboard card and we'll be delighted to cash your check," he told me.

Why was I so obedient?

The next step was a phone call to the manager of the branch where I had opened the account. He told me that I was given the password when I requested the card. I said, not very nicely at this point, that I had never asked for the card.

A quick check with the computer indicated that a personal identification number had been issued. However, for security reasons, Mr. Branch Manager didn't have access to it. He ended by telling me that he would get back to me as soon as possible. When he hung up I still didn't know my PIN and neither did he. A few days later an envelope arrived from the bank. Inside I found a form entitled "Request for Change of Personal Identification Number" and nothing else. You need the old number to make a change.

I no longer do business with this bank. — *Leslie D. Ball* □

Donn Parker, a researcher at SRI, Inc. and a leading authority on computer crime, predicts that EFT systems will be the most vulnerable computer system simply because of the large number of transactions. Already, banks have lost significant amounts of money from machine malfunctions, computer programming errors, and the improper or illegal use of debit cards.

While the losses from any one ATM transaction are small, large losses can result from insiders manipulating the system. Stanley Mark Rifkin, an independent computer security consultant, worked for the Los Angeles-based Security Pacific Bank. In December 1978, the bank discovered that Rifkin had stolen $10.2 million by manipulating the EFT system.

By making transfers of less than $1 million — small transactions by the bank's standards — Rifkin was able to divert the funds to a New York bank and then to a Swiss bank. While awaiting trial, Rifkin was caught attempting a similar fraud on the Union Bank in Los Angeles that would have resulted in a transfer of $50 million to his account at the Bank of America in San Francisco.

Although the systems have many safeguards, "irregularities" like these can happen. Most often they result from abuse of employee passwords or from failure to follow the controls that are built into the systems. Also, collusion among employees can produce the same results.

The part of an EFT system most vulnerable to security problems for the consumer is the personal identification number (PIN). This number, or series of letters, is used by the consumer with her debit card to gain access to her banking files and make a transaction. Bank employees such as computer programmers, mail clerks, and secretaries have access to the customer's PIN when she opens a new account. Other people can find out the PIN simply by watching the customer punch it into a machine. To solve this problem, some banks have installed sliding doors, making their machines similar to voting booths. Banks urge customers to memorize their PIN numbers, but surveys of customers in Wisconsin and Syracuse, N.Y. showed that more than 50 per cent

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wrote their PIN number on their debit cards or kept it in their wallets. A mugger, then, could have access to a person's life savings.

Fortunately, there are ways to prevent others from obtaining and using the customer's PIN. Within the bank, the duties of issuing new cards and numbers can be separated so that no one in the bank ever has access at the same time to both the card and the PIN.

Most desirable, however, is the system now used by most banks which allows new cardholders to select their own PIN when they first use the ATM. The customer is encouraged to use her birthdate, marriage date, child's birthday, or spouse's or child's name — in other words, something that doesn't need to be written down to be remembered. The cardholder's name is the worst possible choice, as a thief will usually guess that first.

Intangible Evidence

One problem with EFT is assignment of liability, but a new federal law is a first step is this direction. In the case of unauthorized transfers, for example, the new law limits consumer liability to $50 and sets a 10-day limit for institutions to begin investigating reported errors. To further delineate consumer rights, the National Commission of Electronic Fund Transfers (NCEFT) — established in 1974 by Congress to study EFT and make public policy recommendations — stated that "the rights and responsibilities of consumers participating in EFT systems should be fully disclosed to them in clear and conspicuous writing when an account is opened."

Another issue that limits consumer acceptance of EFT systems is concern about losing control over funds. With automatic deposit of paychecks, the consumer does not know whether the system is reliable enough to get his money into his account when he expects it to be there. When he makes his own deposits, he knows that the money is there and begins writing checks immediately. He has heard too many "horror stories" from friends about bounced checks to believe that the system actually works.

To calm this fear, the bank can guarantee that the funds will be available at a specific time each week or month. Some banks are accepting the full burden of late deposits so that consumers will accept automatic deposit programs.

The consumer is also concerned about what will replace the canceled check as proof of payment. For years banks have told us that a check is evidence of payment. Although the IRS and other organizations have become more accommodating about checks, the public is not aware of this change and has a great deal of misgivings about not having tangible proof. The NCEFT proposes that a functional equivalent of canceled checks, perhaps debit and credit memos, should be sent to the EFT customer periodically. This, of course, would negate some of the cost savings derived from the system.

The EFT system also deprives a customer of the "float" provided by the time lag of conventional check-processing systems. To replace the float, the NCEFT suggests "value-dating," which would allow the consumer to make a transaction and specify a future date for the actual transfer of funds. Several banks currently provide this service. It should be remembered, however, that the float is not a legal right, but rather a characteristic of the current check payment system.

Value-dating would also allow the retention of stop-payment service. The previously mentioned federal law includes a provision for permission to stop payment for preauthorized transfers up to three days before the scheduled transfer.

Electronic Footprints

Another major issue, one that has to be settled before EFT systems can gain wide acceptance, is concern about the privacy of an individual's financial affairs. The potential invasion of privacy with EFT systems, particularly when they are hooked into a nationwide network, is abhorrent to the average customer.

One law that does infringe on the privacy of citizens is the Bank Secrecy Act of 1970. It requires that banks collect, store for at least five years, and report information on individual banking transactions for potential use in criminal, tax, and regu-

latory investigations. The individual's right to privacy in financial dealings has been further jeopardized by the 1976 Supreme Court decision in the case of United States vs. Miller. According to a report by NCEFT, "the Supreme Court denied that an individual has a constitutionally protected interest in transaction information maintained by his depository institution, holding that such information was voluntarily given, that it was the property of the financial institution, and that the individual has no legal standing to challenge the use and dissemination of such information."

In another pertinent Supreme Court case, United States vs. Bisceglia, the court ruled that "the Internal Revenue Service has authority under Internal Revenue Code Sections 7601 and 7602 to issue a 'John Doe' summons to a bank or other depository in an effort to discover the identity of a person whose bank transactions suggest possible tax liability."

To comply with the Bank Secrecy Act, banks relying exclusively on paper-based systems must maintain costly information files on large numbers of checks. To obtain information necessary for tax and criminal investigations, a paper-based clearing system is inefficient, expensive, and inconvenient. The technology associated with EFT systems, however, makes it economically feasible to maintain an extensive and easily accessible file of a person's financial transactions. Banks can easily comply with the Bank Secrecy Act, and information for investigations of any type is easily transferred. Thus, a payment system whose purpose is the execution of financial transactions can also be used as an inexpensive and convenient source of intelligence.

One such purpose for which a nationwide network of EFT systems is ideally suited is a surveillance system. Paul Armer of the Center for Advanced Study in Behavioral Sciences at Stanford University participated in a team exercise at the Center for Strategic and International Studies at Georgetown University in October 1971. His team was assigned to advise the Russian secret police (KGB) on the design of a system for keeping track of all citizens and foreigners in the USSR. The group recommended the installation of a real-time EFT system for all financial transactions. "Electronic footprints" would then track a person's whereabouts as well as his financial transactions. Obviously, an ideal system for internal Russian spying would not be palatable to the American public.

"What can be done to protect our privacy?" is a primary public concern that has been addressed by the NCEFT and The Privacy Protection Study Commission (created by the Privacy Act of 1974).

Both groups felt that the five-year data storage requirement of the Bank Secrecy Act is too long and that few, if any, banks would go to the expense of doing so if not required by law. A *Federal Reserve Bulletin* suggested that EFT operators should not be forced to retain data for periods longer than necessary for verification purposes. And with less information available, it is less likely that it would be assembled for purposes other than those it was collected for.

The NCEFT also recommended that Congress take specific action to protect individual privacy in this area: individuals should have the right to contest government access to financial transaction information; that notices of summonses or subpoenas should be given; and unless permission is granted, third-party use of information about an individual's finances should be illegal.

Proposals such as these have been enacted or are in bills currently before state and federal legislative bodies. Legislatures must be informed of specific privacy demands before EFT systems safe from "secondary usages" can be mandated.

Legal Environment

Even if banking customers become more receptive to EFT, some legal obstacles must be surmounted before it can become widely available.

One unanswered question is whether state or federal governments should bear the burden of setting standards and enforcing regulations about electronic funds transfer.

There is also a question about whether customer-bank communications terminals should be considered branch banks. Currently, under the

By making transfers of less than $1 million — small by the bank's standards — the thief was able to divert funds to another bank and then on to Switzerland. While awaiting trial, he was caught attempting a similar scheme that would have netted him $50 million.

terms of the 1927 McFadden Act, national banks must adhere to the branching laws established by each state to govern state-chartered banks. If national bank communications terminals were declared not to be bank branches, national banks could gain a competitive advantage by branching across state lines.

State laws that limit bank branches to the county in which the main bank is located, such as those in effect in Massachusetts, obviously limit the spread of EFT. In Massachusetts, full-service ATMs located in supermarkets are considered branch banks and thus cannot be located in counties outside that of the main office.

Several Massachusetts banks have partially overcome this obstacle by forming a holding company, Bay Bank, within which each individual bank maintains its corporate identity. Customers can use the ATM at any Bay Bank; however, they can do things such as transfer money from one account to another only at the bank where their accounts actually are.

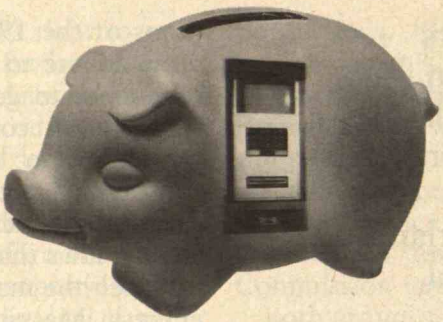
Once a network of EFT systems is established, there is concern about the potential domination by one system. Could a single successful system be subject to antitrust action? Or will this capital-intensive network follow the routes of telephone and electrical systems and become a monopolistic public utility. Monopolistic utilities must, of course, be regulated, and a decision must be made about who should do the regulating.

What's in the Crystal Ball?

The future of EFT systems depends on how well the rights of consumers and the responsibilties of institutions are defined, and on how effectively EFTs are promoted.

The consumer is still skeptical of ATM and POS terminals. The concerns mentioned here are real, and experience has shown that human nature does not take quickly to change. The benefits to banks and retailers are overshadowed by enormous costs. Therefore, growth in this area will continue to be slow.

The growth of ACHs, however, will be much more rapid, especially since the government continues to



The best "passwords" are birthdays, anniversaries, or friends' names.

push their use. In 1979 ACHs processed more than 150 million transactions, compared with nearly 36 billion checks by the Federal Reserve System. The government will continue to encourage direct deposit of its checks since this saves $.12 per transaction. In government programs that use ACHs, an average of 25 per cent of payees currently use the system and the goal is 40 per cent by mid-1981. If that goal is met, the government will save $29 million annually. Salary and pension programs of the Air Force have a participation rate as high as 74 per cent. Obviously this number of transactions provides economies of scale not available to a shoe store owner in Topeka.

ACH activities will increase because of economic forces, and competition will force growth of EFT services. For example, if several retailers use check verification, check forgers will go to other retailers. And when the bad check rate gets high enough among nonparticipating retailers, they will be compelled to use check verification as well.

We will never become a paperless society, but we can substantially reduce our dependency on cash and checks over the next 20 years.

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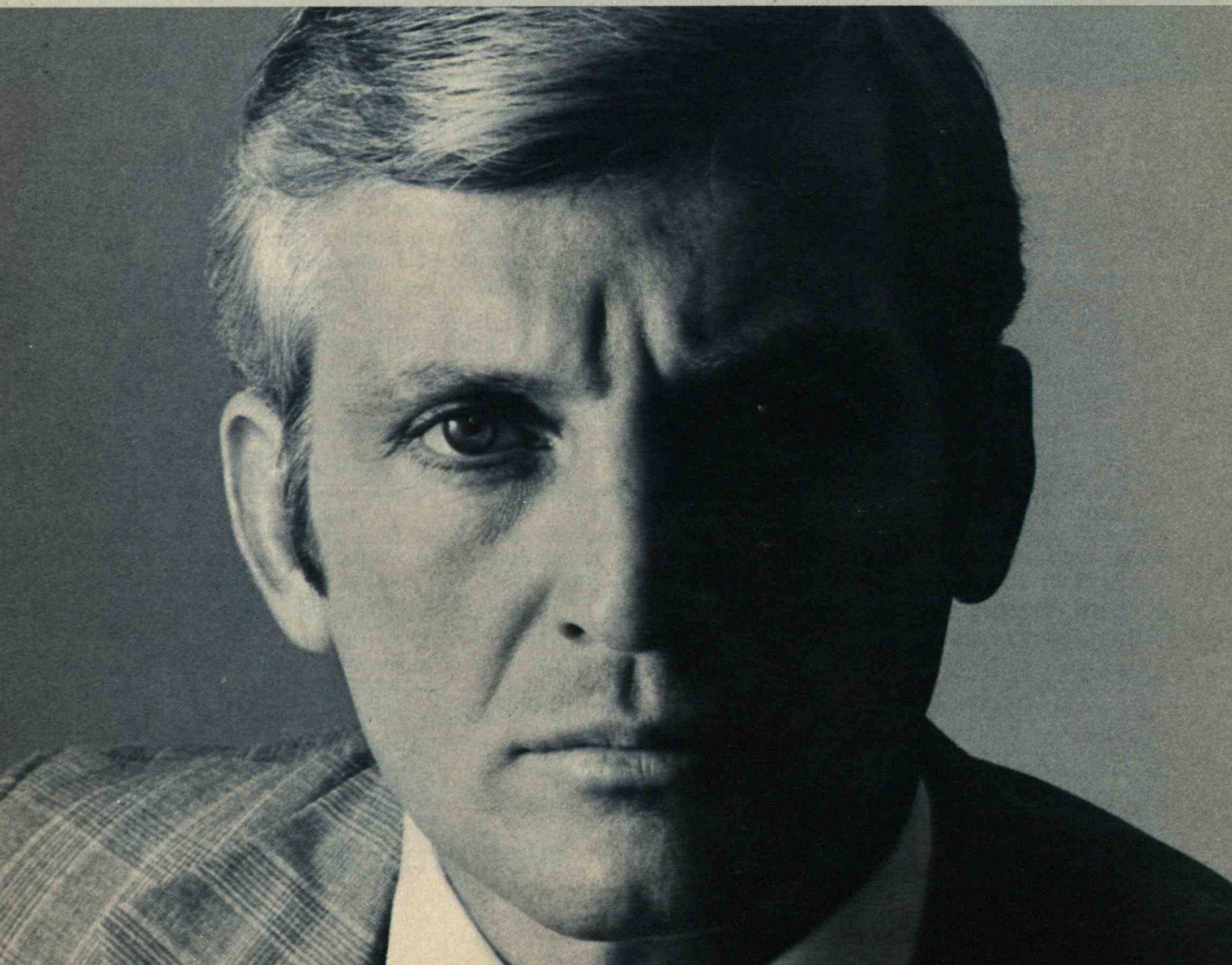

W TO LISTEN THAN TWO EARS.

of trouble. For example:

We prejudge—sometimes even disregard—a speaker based on his delivery or appearance.

We let personal ideas, emotions or prejudices distort what a person has to say.

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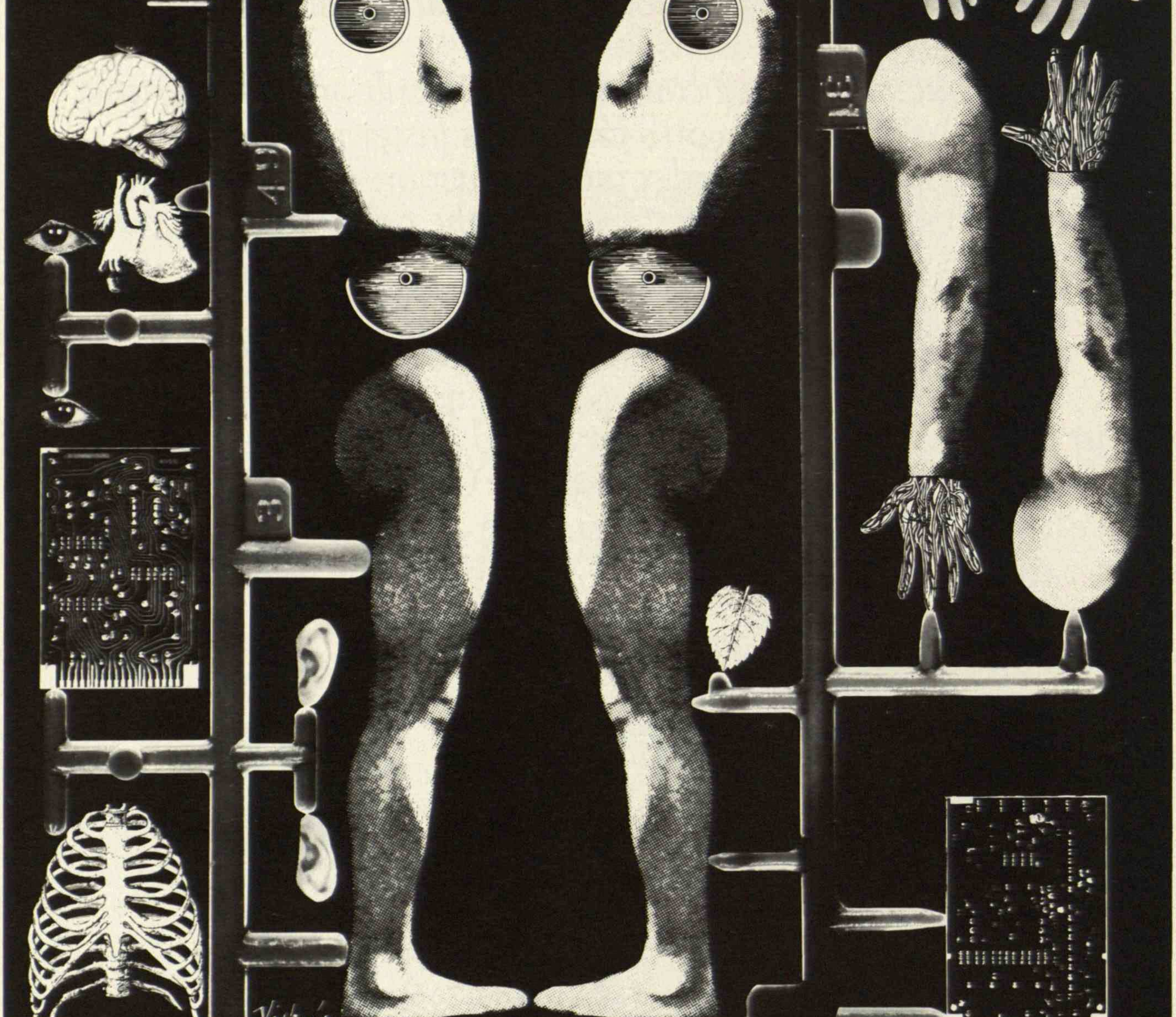


Illustrations: Gary Viskupic

New Genetic Technologies: Prospects and Hazards

by Jonathan King

During the past 30 years we have witnessed extraordinary advances in knowledge of fundamental biological processes, particularly at the cellular and molecular level. These advances have derived in large part from the major investment of public funds in the training of biomedical scientists and support for biomedical research, conducted by the governments of the industrialized countries since the end of World War II. The 1978 budget for biomedical research in the U.S. is about 3 billion dollars. This is one thousand times the federal expenditure for biomedical research in 1948.

In the U.S., these programs originated in the pressing need for coordinated biomedical research to deal with the immense damage suffered by soldiers during and after World War II. The federal funding and encouragement of cooperative, organized research ventures was highly successful and continued after the war, when public pressure overcame opposition from the private medical sector.

The well-financed program of training and research has led to: the elucidation of the chemical structure of the genetic material, DNA; the understanding of the organization of the genetic material in linear segments, the genes; the recognition that genes are blueprints for the structure of protein molecules, which form both the building blocks and working parts of cells; the understanding of the roles of the thin membranes that divide cells into different compartments; and enhanced knowledge of the organization and functions of the complex ribosomes, themselves composed of more than 70 different kinds of protein molecules, which serve as the factories for assembling new proteins according to the instructions of the genes. Thus, the mental and physical labors of tens of thousands of laboratory workers have revealed the extraordinary richness and creativity of the mechanisms by which living things

Although the scientific community generally views recombinant DNA technology as a feature of research, private corporations have moved rapidly to exploit it.

reproduce themselves and interact with their environment.

In the industrialized nations, the major steps in cutting infant mortality, increasing the life span, and controlling infectious disease occurred earlier in this century. These resulted from economic struggles, led principally by the trade unions, for an improved standard of living — notably the shorter working day, increased wages, and improved working conditions. They were aided by public health professionals who fought for improved sanitation, water supplies, and food, thereby helping to eliminate cholera, diptheria, scarlet fever, and other scourges of the urban poor.

The more recently acquired understanding of the biochemistry of bacteria and the role of viruses in human disease, and the development of tissue culture technology for growing cells and viruses in the test tube, laid the basis for eliminating a further set of diseases: polivirus infections in the 1950s; rinderpest virus, a major killer of African cattle, in the 1960s; and more recently, the dramatic eradication of smallpox. (Twenty years ago in India alone there were 150,000 cases of smallpox, causing 41,000 deaths.) The elimination of rinderpest and smallpox viruses resulted from campaigns organized and coordinated by the United Nations.

The scientific basis now exists for mounting research campaigns against viral diseases such as Rift Valley Fever in North Africa, yellow fever in Central Africa, and hemorrhaggic fever in Asia, as well as such widespread parasitic diseases as schistosomiasis and filariasis, including one of its more tragic forms, river blindness.

Of course many of these diseases are intimately associated with particular conditions of life — local housing, agriculture, water supplies and sanitation, and nutrition. Increased knowledge of the biochemistry and physiology of particular organisms does not substitute for the need to study the interrelationships of organisms within ecosystems as well as the social and economic conditions of human society.

Smallpox infects only humans for example, enabling all potential hosts to be identified and vaccinated. Many of the other viruses that affect humans also live in insects or animals and other parts of the ecosystem. These cannot be eradicated by the same strategies used for smallpox. Cholera provides another example: it is still a major problem in Calcutta, where the virus was first isolated in 1817. Indian scientists understand the microbiology of cholera, but the poverty that is partly the legacy of British imperialism must be overcome before the disease can be eradicated.

Another major contribution of modern molecular genetics and cell biology is the recognition that much of human cancer is due to damage by external agents to the genes of human somatic cells. These agents include industrial chemicals such as aniline dyes, which cause bladder cancer, vinyl chloride, which causes liver cancer, and most forms of ionizing radiation. For example, high levels of leukemia and bone cancer are found among survivors of the Hiroshima and Nagasaki holocausts and among people repeatedly exposed to nuclear testing. Other cancers from excessive medical irradiation and exposure to mismanaged nuclear waste will likely manifest themselves in coming years.

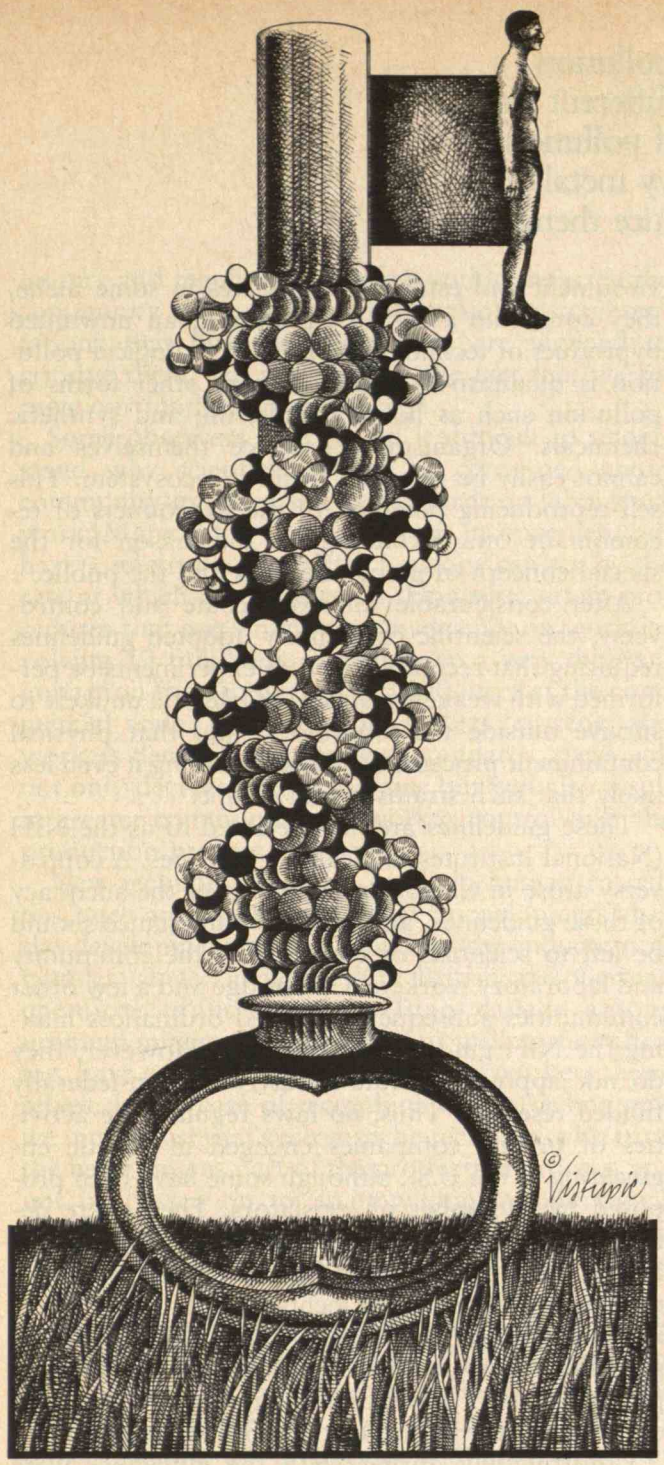
These major breakthroughs have led to the recognition among a sector of the scientific community that much human cancer is preventable. Unfortunately, powerful economic forces have vested interests in the continued production and sale of these agents. Therefore, the prevention of cancer will involve a social struggle similar to those earlier in the century for better working conditions.

In the United States, we do not have a national system of comprehensive medical care. This limits our ability to realize the fullest fruits of our biomedical research. Without a comprehensive health care system, it is difficult to couple research to health care needs. When substantial advances occur, they are sometimes available only to economically advantaged groups. Farm workers in Texas, for example, have an average life span many years less than the national average.

Recombinant DNA Technology

The growth of biological knowledge has engendered the development of very sophisticated biochemical genetic technologies. These technologies, which are today tools for the accumulation of knowledge of organisms, are also the tools for the genetic and biochemical modification of those organisms.

The most dramatic and revolutionary of these technologies is recombinant DNA technology, or genetic engineering — the ability to incorporate segments of DNA, i.e., genetic material, derived from one organism into the cells of another organism. The donor and recipient may be closely related (for example, two strains of bacteria), or they may be very different (for example, a mouse and a bacterium).



Recombinant DNA technology — "genetic engineering" — is the ability to incorporate segments of genetic material from one organism into the cells of another.

Members of the same species exchange segments of genetic material regularly; this is the biological basis of mating and sex — the exchange of equivalent segments of genetic material of parents, generating new genetic combinations in the offspring, which may prove advantageous in adapting to a changing environment.

However, exchange of genetic material between members of unrelated species is rare. Organisms adapting to different environments — to different niches, to use the ecologists' term — evolve different "instructions": different genes. Exchange between such organisms is generally not useful, and therefore rarely observed in nature.

Recombinant DNA technology is useful in biological research, however. Suppose I am studying how pancreatic cells produce insulin and why liver cells do not. I might remove the pancreas from a mouse, and extract from the pancreas cells the long, stringy DNA molecules that represent the blueprints for being a mouse. By treating the isolated DNA molecules with a special protein catalyst, the DNA can be cut into shorter pieces, with the cut ends left sticky. Using similar techniques, I can isolate DNA molecules from a bacterium, whose cut ends are also sticky. Usually this bacterium will be common in the human gut, and called E. coli. On mixing the two tubes of DNA, the sticky ends of mouse DNA will join with lengths of bacterial DNA. Such molecules, containing the genetic material of two different organisms, are termed "recombinant DNA" molecules.

These recombinant molecules can then be reincorporated into a living, growing bacterium. When the bacterium divides, it will reproduce its own DNA, and also reproduce the piece of mouse DNA, or gene. If we isolate the bacterium and incubate it in some beef broth, the next morning we will have 100 billion daughter cells. Each of these will have an identical copy of the mouse gene. Molecular biologists speak of this as "cloning" a mouse gene.

Because bacteria, despite their complexity, are vastly simpler than mouse cells, the techniques of chemistry and biochemistry can be used to study the mouse gene and sometimes the protein whose structure it encodes. From these studies, we might learn about what signals turn this gene on in some cells and off in others. We might also get some hint as to how the genetic information stored in the nucleus of a cell provides the blueprint for the three-dimensional structure and function of the cell.

This technology requires no more equipment than is found in a common college microbiology labora-

Biological pollution is qualitatively different from other forms of pollution, such as heavy metals. Organisms reproduce themselves.

tory. Therefore, it is being used in a vast variety of research situations. Furthermore, recently developed techniques make it possible to transfer in the *other* direction to introduce DNA of a bacterium into a mouse cell. Similarly, one can introduce DNA from one species of mouse into another, or transfer small segments of DNA from human cells to mouse cells or other human cells. This technology, developed originally from microbiology and molecular genetics, provides the technological basis for human genetic manipulation. Because of the intense level of research — hundreds of laboratories are using these techniques to study the genes of animal cells — experiments labelled "impossible" become routine six months later.

Commercial Exploitation and Biological Hazards

Though the scientific community generally views recombinant DNA technology as a research tool, private corporations have moved rapidly to construct and market strains of economically or agriculturally valuable organisms and their byproducts. In addition to the activities of small venture firms and most of the pharmaceutical industry, substantial investments have been made by transnational corporations such as International Nickel, Standard Oil, and Imperial Chemical Industries. A well-publicized case in the drug industry is Eli Lilly Corp.'s plan to grow strains of E. coli bacteria containing insulin for sale to diabetics. Strains have already been constructed or isolated that contain the human insulin gene and that synthesize the protein and export a version of it outside the cell. Lilly believes this will be less expensive than its current practice of extracting insulin from the pancreas of beef cattle. The sale of insulin to diabetics is a $100-million-a-year business.

As most people know, there has been substantial debate over recombinant DNA technology. The debate has centered on whether bacteria incorporating foreign DNA constitute new hazards to humans or to other species in the ecosystem. For example, though E. coli is a normal inhabitant of our intestinal tract, certain strains are the causes of infantile meningitis and diarrhea, urinary tract infections in women, and serious bloodstream infections in hospital patients. In many cases, the pathogenicity of these strains stems from the parasites — derivations of wild strains — that they harbor. Were such strains to synthesize and export insulin, they could well cause additional damage.

To the extent that such strains escape into the environment and establish themselves in some niche, they constitute a form of pollution, an unwanted byproduct of technology. But such biological pollution is qualitatively different from other forms of pollution such as heavy metals, oil, and synthetic chemicals. Organisms reproduce themselves and cannot easily be removed from the ecosystem. This self-reproducing potential of the byproducts of recombinant DNA technology is the reason for the special concern of many scientists and the public.

After considerable internal debate and controversy, the scientific community adopted guidelines requiring that recombinant DNA experiments be performed with weakened strains of bacteria unlikely to survive outside the laboratory, and that physical containment procedures be used, making it even less likely that such strains would escape.

These guidelines are now referred to as the NIH (National Institutes of Health) guidelines. A controversy arose in Cambridge, Mass. over the adequacy of these guidelines, and whether compliance should be left to scientists or overseen by the community and laboratory workers. Cambridge and a few other communities subsequently passed ordinances making the NIH guidelines mandatory. However, they do not apply to private industry or non-federally funded research. Thus, no laws regulate the activities of private companies engaged in genetic engineering in the U.S., although some have been proposed by a number of legislators. These were defeated by the combined influence of the corporations and a wing of the scientific community more interested in exploiting the technology than in protecting the public. In Great Britain, however, these guidelines apply to the entire country, and are supported by the Trade Union Congress and strengthened by representation of the workers involved.

Unfortunately during 1979 the guidelines were severely weakened by the efforts of a group of scientists actively engaged in the development of recombinant DNA technology in alliance with commercial interests. These scientists first argued that the risks are trivial, since the guidelines prevent the construction or release of hazardous strains. This argument was then switched around: since the risks are trivial, there is no need for strong guidelines. The negative outcomes of a few risk-assessment experiments were widely publicized, while the positive results reported in the same studies were actively ignored and suppressed. The guidelines have now been so weakened that rather than protecting public health, they in fact protect those engaged in the technology from public

inquiry and regulation. The few within the scientific community who understand the major misrepresentations that have occurred, and are inclined to critique them, are inhibited by the fact that we receive our funding from the NIH.

Some observers have found it difficult to understand why scientists should be concerned about community-imposed safety standards on laboratory work. Many safety constraints are inconvenient but have a relatively minor effect, as one can see by the rate at which work proceeds. However, safety procedures that are a minor inconvenience on work involving 10 milliliters of cells have a very different impact on the production of 1000 liters at the commercial scale. If concerned scientists, citizens, and workers demand strong safety standards, these will not only decrease profit margins but will also result in greater community and worker control over the production process.

New technologies often result in human casualties, such as respiratory damage in coal miners after the development of deep mining, the induction of bladder cancer in workers in British and German chemical industries, and lung cancer among uranium miners. And the costs, as well as the suffering, have generally been borne by the workers themselves. In the case of recombinant DNA technology, we must insist that such costs be reckoned with from the beginning as part of the production process, and not be passed on to an unwilling or unknowing population. It is not just a question of costs versus benefits, but who gets the benefits and who bears the costs.

Attempts to protect capital investments and profit margins distort certain features of the scientific process. A number of the corporations involved in exploiting recombinant DNA technology have obtained patents on organisms and processes, even though all of the developmental work was publicly financed. The scientists involved simply disassociated themselves from public funding and entered into relations with private companies, thus appropriating public knowledge for private accumulation of wealth not generally available to academic scientists.

Although some scientific/industrial spokespersons have called for the unfettered (and unregulated) "search for truth," the controversy over recombinant DNA technology is not about freedom of enquiry; it is about regulating those who want to rashly exploit for private gain the fruits of knowledge that should belong to all.

Agricultural and Microbial Productivity

A potentially productive application of recombinant DNA and other molecular genetic technologies is the development of new strains of plants and microorganisms. The danger here is familiar: the strains developed in the industrialized countries will be designed for capital-intensive agriculture, thus requiring chemical fertilizer, pesticides, and the destruction of many indigenous ecosystems. But the most productive uses with respect to preservation of human and natural resources will probably involve less manipulative technologies.

For example, in India, China, and Pakistan, microbial technologies for converting manure and waste into clean gas for cooking, heating, and transportation have been developed with existing bacterial strains. And the residue provides a good source of fertilizer. Similarly in India, Burma, and Nepal, very successful projects to fertilize rice paddies have utilized strains of nitrogen-fixing blue-green algae.

If local education and know-how are not commensurate with the sophistication of the imported technologies, proper investigation will be unlikely, and it will be difficult for the people of the developing countries to assert control.

A second danger derives from corporations who move production facilities for modified organisms from industrialized countries to developing countries to escape regulation. Of course, this is done in the name of technology transfer. Ironically, the health hazards of recombinant DNA technology are much more acute in developing countries, where conditions for the spread of disease still exist.

Human Genetic Engineering

The new biological technologies make possible the ultimate modification: the "engineering" of human beings. There is a great deal of research with small mammals such as mice and rabbits, both in introducing segments of DNA into their cells and analyzing the DNA by taking pieces out of the cells and cloning them in bacteria. For example, attempts are now being made to remove bone marrow cells (which form blood cells) from an animal and insert into those cells the DNA segment coding for hemoglobin. The cell with the added segment can be transplanted back into the animal. This is a model for gene therapy of inherited blood diseases such as sickle cell anemia and thalassemia.

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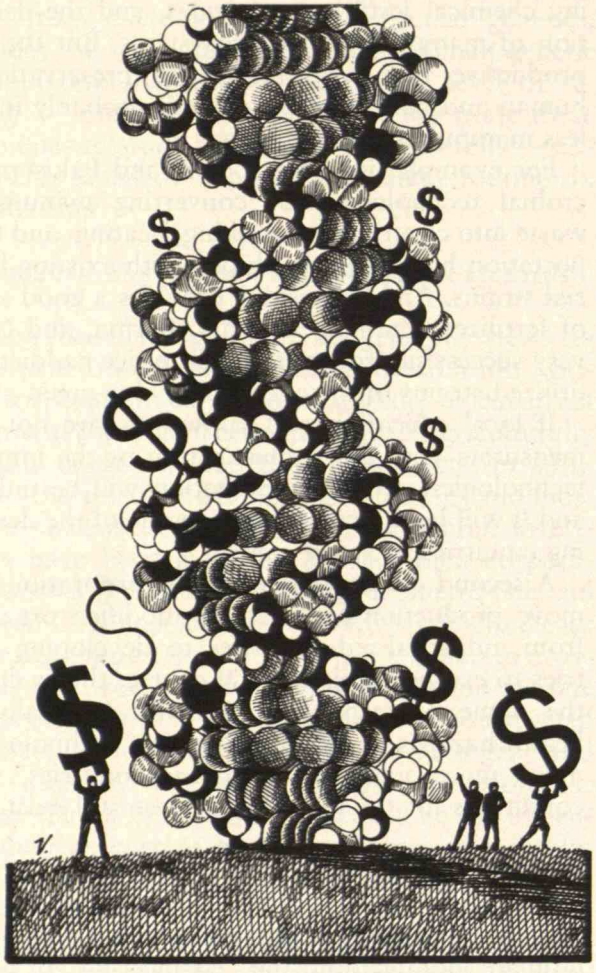
Investors Eye the Fruits of Biological Research

by Robert Cooke



Robert Cooke is the science editor of the Boston Globe.
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The first fruits of modern biological research are beginning to ripen, and scientists, genetic engineers, and a handful of investors expect to start harvesting the results within a year. For example:

- A small company in California — the Cetus Corp., founded and funded solely to exploit the rapid progress in molecular biology — is, hand-in-hand with National Distillers Corp., preparing to make alcohol cheaper than cheap. A pilot plant is now being built near Cincinnati.
- Another small new company, Genentech, Inc., along with the pharmaceutical giant, Eli Lilly & Co., is seeking permission to start making large quantities of human insulin, using tiny tailored bacteria as their factories. If all goes well, some observers expect new supplies of human insulin to become available for diabetics by next spring.
- Genentech, Cetus, and other biology-based firms are also hot on the trail of human interferon, a disease-fighting substance that some researchers see as a potentially powerful weapon against cancer and virus infections. As with insulin, interferon would be made by obedient genetically engineered bacteria.
- Cetus, with major support from the Standard Oil Co. of California, is developing a family of enzyme processes that will change the chemical industry worldwide. Instead of using high temperatures and pressures to run chemical reactions, the work will be done by bacteria, or by the enzymes taken from bacteria, at room temperature and normal atmospheric pressure. Energy savings will be substantial.
- A team of researchers at the Massachusetts Institute of Technology has just received a $50,000 contract from the U.S. Office of Technology Assessment for a study of the emerging applied genetics industry. Also involved is the investment banking firm of F. Eberstadt & Co.

Although the industry is still in its infancy, it has already attracted close to $150 million in venture capital, and active research is under way by a dozen drug firms, chemical companies, and small industrial biology groups.

In the not-too-distant future, observers expect such groups to begin producing a huge variety of useful chemicals cheaply and efficiently. Biological processes will also improve the isolation and refining of metals, and even begin producing fuels ranging from hydrogen to hydrocarbons.

A research group in Florida, for instance, is looking at algae that produce hydrogen, which may ultimately be used as fuel. And Melvin Calvin, at the University of California, Berkeley, is investigating some tropical trees that produce diesel fuel directly, without refining. Both sources are probably "improvable" through genetic manipulation or selection. Such applications of biological science seem almost endless, even beyond imagination.

In a discussion of some of the work being done by Cetus, Dr. Peter Farley, its president, noted that the alcohol project was "developed by us on behalf of National Distillers. They funded the research and own the process and will be working on commercialization of it. We think it's a rather significantly improved process for making alcohol."

Gasohol Possible

Improved, indeed, since the special variety of yeast isolated by Cetus scientists appears to be some 30 per cent more efficient at turning starch into alcohol. Such a development may be of great importance since alcohol, if produced cheaply enough, may in part substitute for gasoline as a motor fuel.

"It's at the point now," Farley said, "where National Distillers is beginning to build a pilot plant in Cincinnati. They hope to have it operational and generating meaningful data this year. Then the commercial decision will be made once we've got the pilot plant functioning."

This special type of yeast was located through use of what is called a cell-sorting machine, a recently invented device that allows biologists to search for interesting mutants in an automated process.

Before long, he added, the relatively new technique known as recombinant DNA technology will be applied to industrial chemical processes. This work involves locating and isolating particular genes or sets of genes, and then plugging them into bacteria. The idea is to make the bacteria manufacture valuable new products they wouldn't normally make.

Genes, the basic units carrying hereditary information, act as the instructions that tell living creatures how to build and operate themselves. Manipulation of DNA, the basic molecule of which genes are made, is becoming known as genetic engineering.

Human Insulin Breakthrough

Observers of this infant industry say the appearance of bacteria-made human insulin is imminent. It is understood by those in the business (though it has not been publicly announced) that Genentech and Lilly have been given permission to run their experiments in large batches.

According to a set of guidelines promulgated by the National Institutes of Health, researchers should not use batches bigger than 10 liters in recombinant DNA experiments. Special exemptions, however, may be granted on a case-by-case basis.

It is also widely rumored but unconfirmed that U.S. laboratories are about to announce production of human interferon in bacteria. Cetus, for example, has an aggressive research program under way in this area, as do Genentech and the huge pharmaceutical firm, Hoffman-LaRoche.

Because of such activity, the investment community is beginning to take a strong interest in the companies involved. The promise of biology-based industries was explored recently in a special symposium run by E. F. Hutton & Co. in Washington. Enthusiasm was rampant.

A few major companies have seen the light and have already bought in. Cetus is now about 60 per cent owned by National Distillers, Standard Oil of California, and Standard Oil of Indiana.

Last summer, too, the Schering-Plough Corp., a pharmaceutical firm, spent $8 million to buy a piece of Biogen, one of the newest of the genetic engineering firms. Biogen, now staffing its new research facilities in Switzerland, is also 23 per cent owned by Inco Ltd.

In addition, the Koppers Co. has invested $2 million in a firm called Genex, and Emerson Electric, Monsanto, and Aetna are smaller investors in Genex and Genentech.

The DuPont Co. also is reported to be in the final process of hiring staff for a genetics laboratory that is expected to be operational sometime next year. Ralph W. F. Hardy, associate director of research, said DuPont expects such biotechnology to produce agricultural chemicals, fertilizers, pharmaceuticals, and medical diagnostic chemicals.

"The world is starting to wake up to the fact that biology is liable to have some influence on our day-to-day lives," Farley, of Cetus, says. Perhaps even more promising, he said, is Cetus's $15 million project with Standard Oil of California (Chevron). This work, aimed first at finding a biological means of producing ethylene glycol (automobile antifreeze), is considered merely the opening round in a concerted assault on the chemical industry.

"What we're talking about basically is oxygenating double bonds, taking a chemical with a double bond, opening the bond, and inserting an oxygen," Farley explained. "Many, many plastics are made this way, as well as such things as antifreeze and ethylene glycol." The bottom line, really, is that for a vast number of chemicals, somewhere in their history is the oxygenation of a double bond. This is the basis for a significant piece of the chemical industry.

There are three or four basic processes in use today that carry out that reaction, Farley says, and the reaction is normally run at high temperature and high pressure, "meaning high energy and high cost. In this day and age worldwide, it represents $5 billion worth of business.

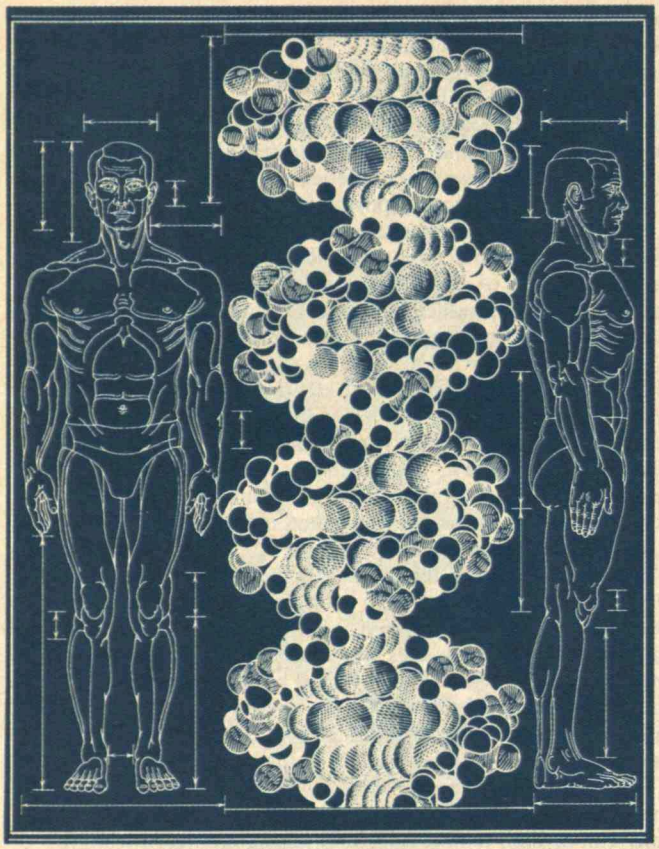
"So, along comes Cetus, and we've developed a totally biologic approach for doing the same thing, requiring low energy because it's done at room temperature and at atmospheric pressure. Obviously, the energy requirements are significantly lower."

Another problem with today's high-energy chemical processes, he adds, is that, in many instances, they're dirty. Chemical industries often spend up to a third of their total capital investment in cleaning up the waste products of such processes. "In our process," however, says Farley, "there's no dirty waste associated with it at all."

The system is based on making, isolating, and tying down various enzymes, or single cells, and then passing the chemicals over them to be changed. Enzymes are catalysts that are active in biological systems.

"What we're doing is getting rid of the big fermentation tanks" usually associated with biology-based processes, Farley says. "We extract enzymes from various microorganisms and use these enzymes as biological catalysts."

In the antifreeze-making process, for example, "we simply pass ethylene gas or propylene gas across a bed of these enzymes and it forms your end product."



A "defect"
in one society
can be desirable in another.
In the U.S., for example,
the sickle cell trait
is considered defective,
while in central Africa it
is necessary for
survival in
malaria-infested areas.

The use of genetic technologies on human beings will expand in the medical sector far more rapidly than anyone can accurately predict. This will alleviate the suffering of a small number of individuals but will also generate many moral and social dilemmas.

The development of human *in vitro* fertilization by Edwards and Steptoe has vastly increased the potential for human genetic manipulation. One can obtain in the test tube the earliest stages of a human embryo. By introducing DNA, or cells altered in the laboratory, into this embryo and then reimplanting the embryo into the womb, the possibility exists for introducing genetic change in most of the cells of the body — including the germ-line cells. Thus, changes would be passed on to subsequent generations.

Prior to the genetic manipulation itself, the use of DNA technology to physically analyze the DNA of human cells will vastly increase. Some of this analysis will be used for screening purposes, as in rare cases where the change in the DNA and the relationship to disease is known (in certain rare inherited blood diseases, for example). Instead of examining the blood in the already mature fetus, we will examine the DNA of the cells of the early embryo or the parents.

Researchers will be confronted by the full range of genetic variation among individuals. What constitutes a genetic defect and what constitutes genetic variation? Historically, the value of many genetically determined features such as skin color and hair character were socially determined. What is a defect in one society is a desirable characteristic in another. At the biological level, the sickle cell trait is considered by some a genetic defect in the United States. But in central Africa it is necessary for survival in malaria-infested areas, rendering the blood cells resistant to the malarial parasite.

Another problem is the distortion of the true causes of human disease. Genetic engineering technology will focus attention on affected individuals and their genes. As a result there will be a strong tendency to lose sight of the agents that caused the damage in the first place, such as mutagenic and carcinogenic chemicals and radiation. Most problems are not with our genes; they are in recreating a society in which the genes of individuals are protected from unnecessary damage. It is critically important that the ability to identify genetic damage serves as a first step in identifying the *cause* of the damage wherever possible, and removing it from the ecosphere.

Note that not all conditions resulting from damage to genes are inherited. If the egg is damaged, resulting in altered chromosome composition, as in Down's syndrome, this is not passed on to the next generation.

Reordering Priorities

We must support every effort to expand and increase knowledge of the functioning of living things and their interactions with the environment, and of the effect of human society on these interactions. This knowledge must be available to all the peoples of the earth and not just a technocratic elite.

At present, a number of the most potent biological technologies are being developed by transnational corporations and institutions who serve private gain rather than social and economic justice. To select what is needed in a particular area will require very broad biological, ecological, and agricultural education. The same lessons that many peoples of the world have learned with respect to the import of technologies of resource exploitation will have to be applied in this field if the fruits of biological knowlege are to be used to attain an equitable, participatory, and sustainable society.

Citizen participation in the decision-making processes, whether on biohazards committees, protection-of-human-subjects committees, or other appropriate forms, must be encouraged. Appropriate support on an international level might be achieved through efforts of the International Labor Organization, the World Health Organization, and the United Nations Agency for Development. In the United States, it is critically important to involve the Environmental Protection Agency and the Occupational Safety and Health Agency in the regulation of genetic technologies. NIH lacks the experience and inclination to regulate a burgeoning multimillion-dollar industry.

In the area of human experimentation and genetic manipulation, we must ensure that the development of very sophisticated technologies for helping a small number of individuals does not obscure the pressing need for eliminating widespread causes of disease and genetic damage. An appropriate form might be task forces on protection of the genetic inheritance from environmental and social damage. This will entail input into the setting of priorities in biomedical research (i.e., what technologies to develop) and not just into the use of technology that is *already* developed. Today we can transplant kidneys, but we cannot prevent kidney disease.

Public health, social ethics, and the problems of underdeveloped rural societies are not the highest priority of experts in molecular genetics and antibiotic production. We must insure the fullest participation of different sectors of society in the development of biological technologies, not as a cosmetic nod to democracy, but because this is the only way to maximize the social benefits and minimize the risks. We are entering a new era of direct modification and design of organisms. These endeavors will require new social forms and the development of a much higher level of democratic process within the technological sphere.

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Proposed economic reforms make realization of China's development goals more likely. And for would-be foreign investors, there are grounds for cautious optimism.

Postage stamps are everywhere vehicles for national propaganda, but Communist and Third-World nations — China notable among them — have outpaced us all. The illustrations accompanying this article show how China has used this medium to celebrate its new aspirations for technology and industrial development.

China's New Economics

by Karel Kovanda

In developing their national economies, Communist countries have in general followed the lead of the Soviet Union — some, like Yugoslavia, have done so only for a limited time; others, like China, have made serious adjustments to suit their local conditions. The model, however, is usually recognizable. Its main features include state ownership of almost all means of production with little, if any, room for private initiative; priority to heavy industry; centralized decision making, enabling the entire country to be run as a single giant corporation; and economic activity directed by the state plan, with market forces ignored.

Yugoslavia abandoned most features of this model after its rift with the Soviet Union in 1948 and developed its own idiosyncratic ways of building communism. Since the early 1960s, other Eastern European countries, and even the U.S.S.R. itself, have experienced economic problems that led to a reexamination of the system of management and planning and, in several instances, to the introduction of major economic reforms. In all countries, these reforms were aimed at improving the quality of management; in several (most notably in Hungary and Czechoslovakia), they were aimed also at decentralizing decision making, thereby both decreasing the influence of the state plan and central governmental authorities and increasing the role of supply and demand.

China never adhered to the Soviet model blindly; its own unique qualities could not be ignored. It has been a tradition for the Chinese to critically examine the practices of the Soviet Union before accepting them. In 1956, for example, years before the two countries split openly, Mao Zedong gently criticized the U.S.S.R. for certain mistakes, especially in agriculture. These mistakes, he said, China would not repeat. Nevertheless, despite their reservations, the Chinese have run their economy far closer to the Soviet model than to any other.

Eastern European economic reforms began while China was in the throes of the Cultural Revolution — during the second half of the 1960s. At that time the Chinese considered the Eastern European countries thoroughly "revisionist," and their reforms were summarily rejected as a throwback to capitalism. Sun Yefang, a Chinese economist who in the early 1960s had recommended reforms of a similar type for China, was summarily thrown into prison.

The word "market" is not often used
— it still perhaps carries the taint of revisionism —
but the message is clear:
market forces of supply and demand must be
heeded in the national economy.

Today, a dozen or so years later, the Chinese too have started reexamining their economic system. Criticisms are now voiced publicly and frequently.

Here is a sampling of some of the problems voiced in the Chinese press these days (and one could continue endlessly):

☐ Zhu Yonfei, a director of a factory that makes power station equipment in Harbin in northeast China, spent a total of 80 days in Peking during 1978 attending various meetings; these proceedings were in addition to meetings on the provincial and the city level. In the course of eleven months he received 1,125 official documents and over 1,000 assorted communications from his superiors, not counting party documents. In addition, some 70 different inspection groups from national and provincial organs visited the factory during that time.

☐ Construction began in 1971 on a vinyl factory in Lanzhou, the dreadfully polluted capital of Gansu province in China's west. Scheduled to be finished in five years, the factory is today, eight years later, still under construction, and costs have so far been twice the original estimate.

☐ A recent news item mentioned once again an improvement to an imported herbicide first proposed ten years ago by the Institute of Biology of China's Academy of Sciences. Production of the improved article is still under discussion. The Ministry of Metallurgy, which controls the supply of a key ingredient, has not been exactly cooperative.

Economic Reform

More important than the public attention given to such problems are current proposals to rationalize China's economic management. The key pronouncement appeared in the fall of 1978: a lengthy program presented by Hu Qiaomu, the president of China's prestigious Academy of Social Sciences.

This paper was no mere academic exercise. Hu Qiaomu first presented it at a meeting of the State Council, China's government, which endorsed it as a basis for developing further policies.

The paper was a criticism of unreconstructed Maoists, who argue that human will is all-important and that economic development can, for all practical purposes, be decreed by order. Such mentality characterized the disastrous Great Leap Forward of 1958, which brought the country to the verge of economic disintegration. People who argue for authoritarian management, said Hu, "take the will of society, the government, and the authorities as economic laws which can be bent as is politically expedient." The reality, however, is that economic laws are objective and have to be taken into account when managing the economy.

Hu was struggling here not only against the legacy of Mao but also against that of Stalin. In essence he was fighting a battle that his East European colleagues had joined 15 to 20 years earlier. "If we do not study and abide by objective laws," he argued, "and if we rely on the will of the authorities and issue arbitrary orders, it will cause stagnation or regression . . . in the national economy as a whole and inflict untold suffering upon hundreds of millions of people." Obviously, the "untold suffering" of "hundreds of millions" was no mere hypothetical situation; people still shudder when they recall the Great Leap Forward. It is interesting that the present modernization effort was referred to as "the New Great Leap Forward" only for a short time; now it is described as "the New Long March."

Hu Quiaomu then turned his attention to the way the economy was being managed, drawing a picture of chaos attributed — as is now customary — to Lin Biao and the Gang of Four. Streamlining this chaos, in which everybody gives orders and no one pays any attention to them, requires *strengthening* the role of the central plan in an economy which, according to Hu, is now only "semiplanned." This line of thinking goes against the argument in Eastern Europe, where plans are frequently considered excessively detailed and not flexible enough. In China, however, both centralized and decentralized planning methods need to be utilized. Hu Quiaomu recognizes the existence of diverse interest groups and talks about differences between production and needs, imbalance between supply and demand, and diverse contradictions — between central and local authorities, among departments, and between the state and individual enterprises. Too rigid a plan obviously can not help resolve these differences.

Another leading economist, Xue Muqiao, clarified recently that indirect planning methods will include taxation, price policy, investment policy, credits, and loans — and also supplies of raw materials. In sharp contrast to current practices, the plan should be market oriented: "The present procedure," Xue Muqiao wrote, "is that purchasing plans are based on production plans, and marketing plans in turn on purchasing plans. This must be stopped. In the future, purchasing plans should be based on needs of

the market, and production plans will then be based on purchasing plans. Market sales must not be determined by production plans, but the other way around."

While planning must improve, the "law of value" must be observed, too. This is a Marxist way of saying that goods are exchanged on the market at equal value, which is reflected mostly in their prices. The "law of value" is merely a linguistic term that simultaneously conceals and reveals the real message — that market forces of supply and demand must be heeded in the national economy. Hu himself doesn't use the word "market," a term that still perhaps carries the taint of revisionism; but everybody knows what he is talking about. (Others don't feel the need to be so circumspect: Zhao Zeyang, for one, the first secretary of the party in Sichuan and one of the brilliant emerging leaders of the country, was among the first to call a spade a spade and a market a market.)

Hu Qiaomu is thus calling for a mixed package: he proposes both improved planning and some play for the market forces in managing the economy. The priority of planning, however, is never left in doubt: "Planning must come first, and prices second. . . . Prices serve our plans," he said.

Within the framework of these general principles, specific areas of concern are delineated: the necessity to improve enterprise management; to radically improve cost accounting; to bring into harmony the interests of the state, the enterprise, and the worker; to remunerate according to work done; to streamline existing enterprises by promoting specialization and cooperation; to develop specialized companies; to improve the functioning of banks; to develop economic legislation; and so forth.

The phrase "economic reform" is never mentioned. Nor, as far as I know, has it ever been mentioned in any other economic writings that deal with individual proposed changes. And yet when I asked Chinese economists whether the proposals they make are for isolated changes or whether they amount to comprehensive reform, their response was immediate and unambiguous: comprehensive reform.

China's leaders have repeatedly stressed that modernization in China will not follow the pattern of other countries. Reform will have to proceed with due consideration of China's particular characteristics — of which the overabundance of labor is one. It does not seem likely that the system of "guaranteed employment" (once a worker becomes a part of the

system) is about to be abandoned. But that system will lead to problems for cost-conscious managers who will be saddled with unnecessary hands anxiously awaiting the monthly paypacket. I have been told that if the Anshan Iron and Steel Mill in the northeast, China's largest, were to be modernized, its workforce would have to be reduced by two-thirds. How this would, or even could, be possible, is unclear. Combining the socialist ideal of no overt unemployment with the reformers' commitment to economic efficiency will be a hard problem to solve.

In this respect, China is in a position different from that of East European countries, some of which are starved for labor. On the other hand, its plentiful labor supply might help China eschew one of the most irritating features of Eastern Europe — the lack of services. Service industries make only modest demands on capital investment but are quite labor-intensive, fitting into China's present needs.

Chinese economists are in fact aware of this opportunity. The press has published a number of articles from various provinces describing local efforts to expand services in order to employ high-school graduates who otherwise would have to be sent to the countryside, a fate youngsters try to avoid at all cost. One can only hope that bureaucratic procedure will not stymie these imaginative proposals to organize surplus labor.

New Managers for a New China

An entirely different issue that is conspicuously absent from Hu Quiaomu's reform program is that of management personnel. Until now, management positions and political positions were hardly distinguishable; political reliability was frequently the only skill required. Reform will require a different brand of manager: people who will be at least somewhat conversant with the skills that go with their positions. "Old-timers" will be given every opportunity to learn the needed skills, and the study of Western management techniques is being encouraged. But not all will succeed. It is precisely from these circles that one expects some of the greatest opposition to the reform — that is, from people who will feel most threatened by it.

Hu Quiaomu takes note of the opposition. He mentions the "pernicious influence" of the Gang of Four, the attacks launched by "newborn bourgeois elements," the "force of habit," and assorted "erroneous tendencies." His recipe for dealing with the forces that these labels represent is, however, rather disingenuous: to strengthen Party leadership and put "proletarian politics in command," a classical non-solution.

In reality, attempts at improving management are made, at least at lower levels, by taking a leaf from the Yugoslav book and introducing a measure of industrial democracy. In the fall of 1978, Deng Xiaoping voiced the idea at the Chinese Trade Union Congress that workers on the shop floor should elect their immediate supervisors. But do not suppose from this evidence that the Chinese leadership consists of devoted democrats — or, at least, do not rely on this alone for sufficient proof. I suspect the main reason for introducing democracy to the shop floor is economic efficiency. Studies in many countries have demonstrated conclusively that elements of worker participation in management and even self-management tend to increase productivity and improve performance. The havoc of the Cultural Revolution was such that even today, three years after its end, 24 per cent of China's 300,000-odd state-owned enterprises operate at a loss. This is where involving workers in electing their own supervisors might make a difference.

A case in point is that of the Xinhua Printing Plant in Lanzhou, where "all 9 workshop directors and 77 section leaders are now elected by direct vote by the workers." Importantly, "a large proportion of those newly elected are specialists, innovators, and experienced administrators." This was a subject of a major article in the *People's Daily* earlier this year, accompanied by an editorial. The key point is that since the new flock of supervisors was elected, probably late last year, performance of the plant has improved dramatically. During the first four months of 1979, labor productivity allegedly shot up 46.2 per cent and the total output value 45.2 per cent, compared with the same period in 1978. "For the first time in years, the plant reported a profit," we are told. If this experience can be duplicated elsewhere, it could amount to a considerable boost to the economy — at no extra cost.

Industrial democracy will probably present special problems in China. One wonders about those leaders who are not reelected: will they not lose face — a very important consideration in China? Will workers be ready to take the responsibility of *not* reelecting their present leaders, for that same reason? In this situation, incompetent leaders who are reelected despite their incompetence will find

Reform will have to proceed with due consideration of China's particular characteristics, of which the overabundance of labor is one.

their positions strengthened even further. When the press has focused on shop floor elections that *did* result in changes in management, it has found it necessary to emphasize that not being reelected carries with it neither stigma nor loss of face.

The Dethroning of Steel

No one reforms an economy that is running smoothly. While reforms in Communist countries represent a reaction to economic difficulties, China's reforms are a reaction to a near-disaster. Hua Guofeng has declared that China's national economy was on the threshold of absolute breakdown at the end of 1976. In 1977 and 1978, the first two years after Mao Zedong's death and the overthrow of the Gang of Four, China's industry posted remarkable annual increases of over 14 and over 13 per cent respectively. This was a period of recovering past losses, and these two-digit increases show how great the losses had been. Nevertheless, in 1978 the country's leaders felt confident enough to propose grandiose plans for the future.

In the spring of 1978, the slogan of "four modernizations" was reactivated — i.e., the modernization of industry, agriculture, national defense, and science and technology. The first session of the fifth National People's Congress declared that by the end of the century, China would catch up with advanced world levels. A detailed plan was drawn up for the period up to 1985. The main goals to be attained by then were production of 400 million tons of grain, compared with 300 million in 1978, and 60 million tons of steel, compared with 31 million in 1978.

The emphasis on steel may represent another vestige of the Soviet — more specifically Stalinist — model of development. It was Stalin who in the 1920s and 1930s, contrary to the views of Bukharin and others, forced the U.S.S.R. down the path of forced industrialization, with heavy industry a priority. Even if conducted on a scale more moderate than Stalin's grotesque superindustrialization, this strategy presents important difficulties: it benefits the grandchildren, if anybody, rather than the workers of today, and the necessary funds to support it must be mercilessly squeezed from agriculture, virtually the only available source. But China has never turned completely against the old dictator, and both Stalin and steel were part of the national catechism until very recently. But by the end of 1978 the emphasis on steel was admitted to be misguided, and China's leaders — realizing that they had demanded too much — cut the plans down to size, liberating themselves in the process from another Stalinist shibboleth. The change was enunciated in an important editorial in the *People's Daily* on February 24, 1979. Perhaps the first to propound this line of reasoning, this essay demanded that the entire program of the four modernizations be revamped. Investment in steel had not been paying off, the editorial argued, one reason being that the necessary support industries were lacking. What the economy needed was a profound reordering of priorities, with far greater emphasis on agriculture, energy, transportation, building materials, and "the urgent needs of the people" in housing and schools. Major changes were in the offing.

Political Decisions

Thus in the course of 1979, Chinese economic thinking has been delineating two complementary programs: one for reforming economic management

and one for restructuring priorities in the national economy. Important political decisions have resulted. In June 1979, the fifth National People's Congress in its second session thoroughly revised the economic blueprint for the future that it had drafted only 15 months earlier. Instead of 60 million tons of steel for 1985, only 40 to 45 million are now projected.

The revised outlook proposes that 1979, 1980, and 1981 be years for "readjusting, restructuring, consolidating, and improving" the national economy. "Readjusting" is the code word for balancing the disproportionate growth between agriculture and industry, between various branches of industry, and between production and consumption. "Restructuring" amounts to reform of management methods, essentially as proposed by Hu Qiaomu. "Consolidation" calls for a shake-up of management personnel in inefficient enterprises and thus deals with the one topic Hu Qiaomu had glossed over. And "improvement" means just that: raising levels of productivity, technology, and management as high as possible.

This rethinking of China's economic future is tremendously interesting to political scientists; but it is of even more vital concern to the foreign businesspeople who hope to share in expanded trade with the country. The year 1978 was one of great hopes and expectations: China signed several billion dollars of foreign trade contracts, and the sky seemed the limit. But as the year came to an end, China took a second look at the balance sheet — taking stock of its foreign orders, double-checking how they would be paid for, and realizing that foreign trade would have to be adjusted along with the rest of the economy. New contracts were not signed, and those already concluded — for example, the multi-billion-dollar Japanese project to build the Paoshan steel mill near Shanghai — were reportedly put on ice.

The enthusiasm for wholesale imports evaporated. Conditions specific to China were emphasized, i.e., overpopulation and its extensive industrial plant, no matter how obsolete by today's world standards. Though decades old, this could not be replaced in one felled swoop, and certainly not by modern automated technology that would only exacerbate the extreme shortage of jobs.

Some observers felt that China was drawing back into its cocoon a mere few months after foreign trade had been reestablished. But at the National People's Congress last June, Premier Hua Guofeng stated emphatically that changes in the economy will not mean a curtailing of foreign trade. "The view that this policy of readjustment is a negative retreat, and the view that its implementation will lead to stopping imports of advanced technology, are both entirely wrong. . . . We must learn hard all that is worthwhile from foreign countries, selectively import advanced technology which we urgently need, and not wall off our country from international exchanges."

The key word clearly is *selectivity*. It will now be difficult for some other Bethlehem Steel to conclude another steel-mill contract. However, U.S. industries that have something to offer the new priority areas in China's economy should find that their only problem is West European and Japanese competition. Agriculture, light industry, textiles, building materials, and the "weak links" in the economy — fuels and energy, transport and communications — these are areas with great potential for foreign involvement. In addition to building new facilities, there is tremendous interest in overhauling the existing plant, and importing technology and skills is considered more important than importing complete sets of equipment.

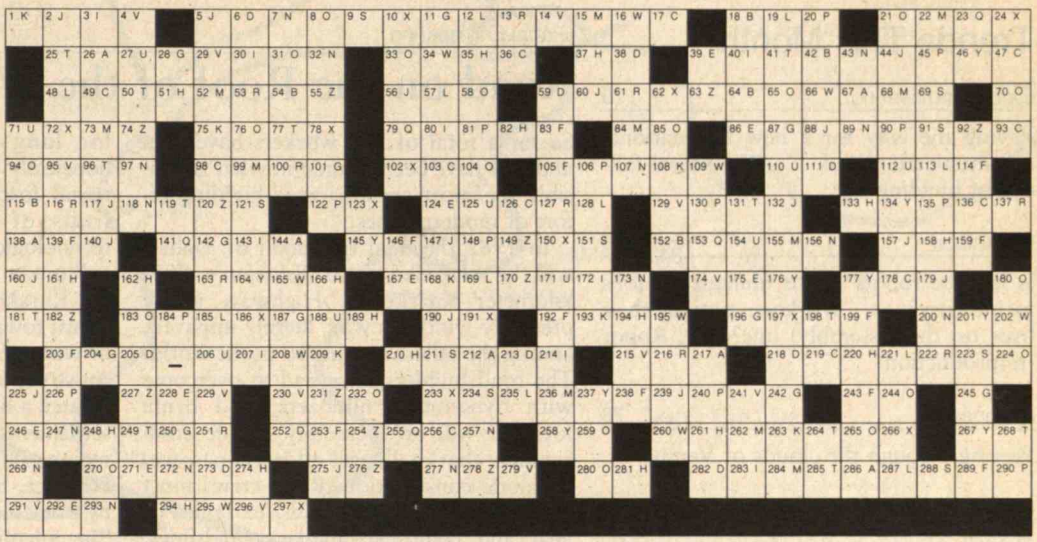
The current economic reforms improve the chances for China to attain its development goals, especially now that these goals have been scaled down to more realistic proportions. But while we focus attention on these changes going on in the country, we must never forget the constants of Chinese economic life. They include tremendous inertia, an agonizing bureaucracy, lack of personal initiative, and the extremely low cultural level of the vast majority of the population. These and other such features present difficult obstacles to modernization, and they are the other side of the coin. Foreigners who know the country intimately are now engaged in weighing these conflicting influences. On balance, this foreigner feels there are grounds for cautious optimism when considering the future of China's economy.

Suggested Reading

Quiaomu, Hu, "Observe Economic Laws: Speed Up the Four Modernizations," *Peking Review*, nos. 45, 46, 57, 1978.

Karel Kovanda has just returned to the U.S. after several years in China working as a foreign expert for Radio Peking. He holds a Ph.D. in political science (1975) from M.I.T.

Alice in a Different Wonder Land



Complete the word definitions; then enter the appropriate letters in the diagram to complete a quotation from an essay on mathematics. The first letters of the defined words give the author and title from which the quotation is taken. Black squares in the diagram indicate the ends of words; if there is no black square at the right end of the diagram, the word continues on the next line.

A solution to this Tech-Crostic will be given in the next issue of the Review, when another of Mr. Forsberg's puzzles will also appear. Readers are invited to comment — and to suggest favorite texts for future puzzles.

A. Downhill sled; serving tray — 212 26 67 217 144 286 138

B. Greek goddess of war and technology — 152 64 18 115 54 42

C. 155-mile river in Virginia — 36 47 219 136 178 98 49 126 103 93 17 256

D. Common yellow wild flower (lit. "little frog") — 252 6 111 59 38 282 273 205 213 218

E. Constellation, scene of 1604 supernova — 271 124 175 86 228 167 39 292 246

F. Characterizing Rhode Island (2 words) — 192 203 139 289 159 146 238 83 243 105 199 114 253

G. Rare earth elements — 204 245 87 196 142 11 250 187 101 28 242

H. Novel by Hermann Hesse, 1943 (2 words, Ger.) — 189 220 37 158 161 82 51 281 210 274 162 294 194 261 133 166 35 248

I. Bombardier in Joseph Heller's *Catch-22* — 40 283 207 214 3 30 80 143 172

J. "But it wasn't, ___ "(Ogden Nash, "Look what you did, Christopher", 5 words) — 60 239 132 56 5 44 190 140 225 157 179 117 2 160 275 147 88

K. Ungainly, clumsy — 193 1 263 75 168 108 209

L. Ammonia derivative, first isolated 1849 — 48 128 12 57 235 169 19 287 185 113 221

M. Implication; entailment; complexity — 15 284 73 84 52 22 155 236 262 99 68

N. Author of Arthurian romances, c. 1170 (3 words, Fr.) — 272 277 156 269 107 7 200 43 247 118 257 173 97 89 32 293

O. ". . shalt surely lend him ___" Deut. 15:8 (4 wds.) — 232 94 65 85 270 33 183 259 76 8 70 224 280 244 58 180 21 265 31 104

P. Having aligned jaws — 130 90 122 148 45 226 106 81 135 184 290 240 20

Q. Character in *Midsummer Night's Dream* — 153 79 255 141 23

R. Assenting; positive — 216 116 61 13 100 163 222 251 127 53 137

S. Novel by Dostoevski, 1871 (After "the") — 288 211 234 121 9 91 151 69 223

T. Allotment of legislators according to population — 198 25 41 181 119 77 131 264 249 96 50 268 285

U. Hard metallic element — 125 206 154 112 188 27 110 71 171

V. "Good bear learned his ____," Milne, *When We Were Very Young* (3 words) — 296 174 230 14 241 4 129 95 229 279 215 29 291

W. Entwine, braid — 295 66 195 202 165 260 208 16 34 109

X. Separation and analysis by selective absorption — 186 78 72 123 10 24 233 102 191 150 62 197 266 297

Y. Feeding organ of brachiopods — 46 176 237 201 267 145 177 258 134 164

Z. Italian-French automobile pioneer (full name) — 92 231 120 227 63 74 149 254 276 170 182 55 278

Trend of Affairs

Trends This Month

Global Engineering

Road on the Roof of the World

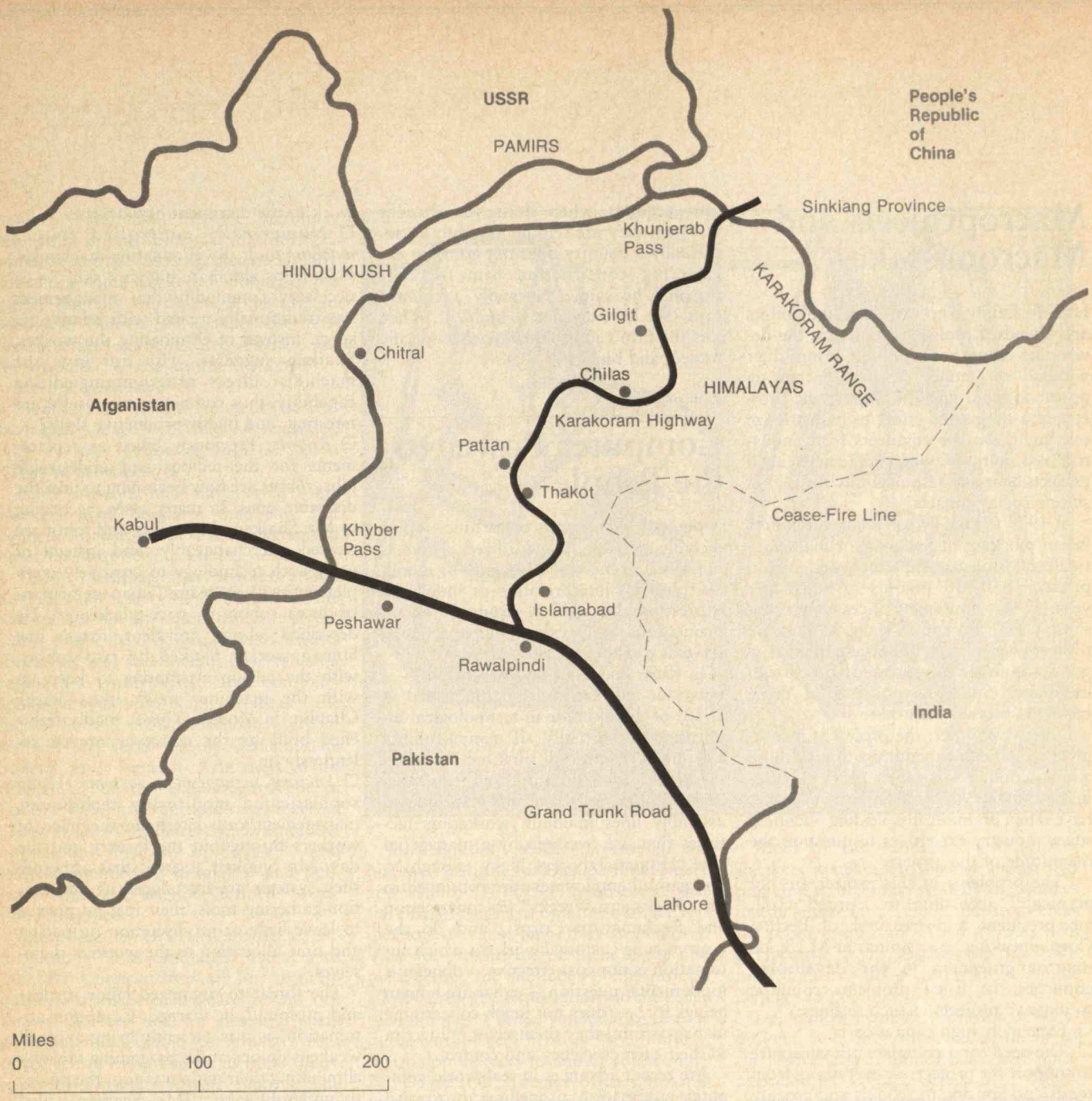
So far a total of 506 workers have died and 314 have been injured in what is possibly the most arduous road-building effort of modern times.

In 1982 the final truckload of asphalt will be shoveled onto Pakistan's 883-kilometer Karakoram Highway, which presently winds its way, largely unpaved, among the tallest mountains in the world. The road builders have had to overcome with dynamite, bulldozers, and brute force of will an incredibly hostile environment that challenges efforts at passage, let alone construction. Road crews must perform despite high winds, extremes of heat and cold, earthquakes, mudslides, avalanches, glaciers, valley walls that slope 70°, and gradients of up to 45°. The blasting and filling has further upset the terrain: some 10 years must pass before the affected mountainsides will stabilize.

Why build a road in such a hostile region? The highway has opened up Pakistan's northern areas for the first time, "bringing these historically backwater areas into the national mainstream," writes Nazir A. Kamal in *Defense and Foreign Affairs*. Says Dr. Kamal, a research associate at the Institute of Strategic Studies in Islamabad, Pakistan, "To leave the region as it had remained, for long centuries cut off . . . and hopelessly exposed to the vagaries of external forces, would be a denial of the fruits of independence and modern technological development . . ."

From a Pakistani national viewpoint, the Karakoram Highway is a Herculean thrust toward modernization — for better or worse. Still awaiting the final stages of construction, the highway has already created a link with previously inaccessible settlements. For example, the Kohistan region, part of the Northwest Frontier Province, has until now been linked only by a few footpaths with the outside world. "Its inhabitants led a bare, subsistence-level existence in a thoroughly sequestered environment," says Dr. Kamal.

More importantly, the highway has linked the nation of Pakistan with the People's Republic of China. Since 1966 China has helped with construction through the Sino-Pakistan Frontier Works Organization. For China, the highway has been a practical exercise in road building that may be a harbinger of similar projects elsewhere. But the challenge is far from over. Even after its completion, the Karakoram Highway will continue to command the attention of Chinese and Pakistani highway crews to keep its sur-



Map: The Karakoram Highway (KKH) joins the Pakistan section of the much older Grand Trunk Road with the Sinkiang Province of the People's Republic of China. Its strategic importance is undeniable in the light of recent political upheavals in Afghanistan and Iran: the KKH is an all-weather highway that can accommodate vehicles weighing up to 10,000 pounds; it is 7 meters wide in the mountainous sections and 4.5 meters wide in flatter sections. **Photo:** A gentle section of the Karakoram Highway, which winds its way among more than forty great mountain peaks that rise over 24,000 feet above sea level. The KKH is supplemented in the Northern Areas of Pakistan by about 2,600 kilometers of secondary roads. (*Photo: Nazir A. Kamal, courtesy of* Defense & Foreign Affairs)

face clear of heavy winter snowfall and rockfalls that occur year-round. Indeed, continuing Chinese cooperation will ensure the project's international significance — one it might have had merely by its crossing into China's Sinkiang Province at the 15,400-foot-high Khunjerab Pass.

Clearly more than reaching remote villages and promoting international fellowship inspired this travail, "one of the wonders of the Third World." The mineralogical richness of the northern areas cannot be overlooked. The lure of iron, chromium, copper, lead, sulfur, antimony, gold, and uranium no doubt played a role in putting the Pakistan Army Engineers on the road in 1959. As Dr. Kamal puts it: "A nation whose technological reach is confined to its limited heartland and [that] is not in a position to mobilize its potentially rich peripheral regions will have its capabilities . . . clearly circumscribed."

One need not search long for another less-obvious motivation: prestige. Dr. Kamal quotes Hilaire Belloc, who wrote in *The Road*, "The material rise and decline of a state are better measured by the condition of its communications, that is, of its roads, than by any other criterion." It was more than a century ago that the last major new highway was built in the region. It extended the Grand Trunk road (a sixteenth century project that crossed the Gangetic Plain from Bengal to Punjab) westward from Lahore to Peshawar. The time was overdue for Pakistan to forge a modern link between its northern areas and the twentieth century. — *L.A.P.* □

Macroprojects and Macromistakes

Like the family who wins a million dollars and spends it foolishly, several of the developing countries may be using their windfall oil money or new borrowing power to build gigantic engineering projects in a misguided effort to industrialize overnight. Do the engineers from industrialized nations who implement such projects bear any responsibility for the resulting social impacts?

In 1973 a large British engineering firm began working in Sudan on a major agricultural project, a superfarm designed to produce 350,000 pounds of sugar per year. At that time sugar prices were rising sharply with no end in sight, so that the project was seen by the Sudanese as a good way to develop products for foreign exchange. (Sudan is not one of those countries blessed with oil.)

Seven years later, the project is incomplete, despite an expenditure approaching a billion dollars — over six times the original estimate. And ironically, sugar prices have fallen dramatically, leading Sudanese sugar industry executives to question the magnitude of the project.

"The problems of this project are not atypical," according to Cordell Hull, vice-president and treasurer of Bechtel Corp. Speaking at a seminar at M.I.T. on macroengineering in the developing countries, he listed problems common to massive projects in such settings:

☐ Extremely high capital costs

☐ The need for a complete infrastructure to support the projects — everything from roads and housing to schools and grocery stores

☐ The complexity of multinational, multifirm involvement

☐ Delays, which can cost up to $1 million per day on a $1-billion project.

After taking all these problems into consideration, Mr. Hull forecast that "many more macroprojects will be mounted in the developing countries, particularly to help alleviate world energy problems."

Many questions can be asked about the appropriateness of such development to these countries' locales and peoples. Indeed, the effects of rapid, forced industrialization, typified by the macroengineering project, may have played a significant role in the Iranian revolution.

Though large engineering contractors *can* take local social and economic issues into account when doing cost/benefit analyses, they are seldom asked to do so. "Usually a country does not go to an engineering construction firm for that reason," he said. "Normally a country says, 'We have decided to build . . .' Then it is the firm's job to analyze that specific project and build it." — *K.R.* ☐

Workplace

Computer Power to the People

A player piano pumps out a tune — predictable, reliable, standardized. There is not much in the way of nuance or mood, no room for interpretation or individual expression. No skill is required and no pianist need apply, except, perhaps, one to serve as a model for the "program."

In Kurt Vonnegut's *Player Piano* — a powerful and early vision (published in 1952) of the ultimate in technological innovation — virtually all manual ability has been rendered obsolete: skilled "workers" are "immortalized" on tape. Production robots and fully automated assembly lines maintain workerless factories that are overseen by a managerial elite. Human laborers lucky enough to find gainful employment are consigned to the "Reeks and Wrecks" (*Rec*onstruction and *Rec*lamation Corps), and do the bottom-rung custodial work for which automation is not cost-effective. Vonnegut's fundamental question — what are human beings for? — does not much concern the managers until they themselves fall victim to their own efficiency and control.

Are recent advances in real-world computer automation propelling us toward this sort of frightening end? Harley Shaiken, a consultant to the United Auto Workers on new technology, maintains that the problem is not computer technology per se but "its unrestrained use in the hands of management." Mr. Shaiken told a recent "Public Forum on Computers, the Worker, and the Union" at M.I.T. that although management may implement such "innovations" in the name of productivity, it is really control "over every minute of the workers' time" that management seeks. In response, labor unions have broadened their concerns from wage disputes to more subtle issues: boredom, alienation, demoralization, and the bleak prospect of becoming much like the fictitious "Reeks and Wrecks."

Mr. Shaiken provided three examples of computer automation that, he charges, work to the detriment of workers:

☐ *Numerically controlled (N.C.) machine tools*. By eliminating machinists, N.C. helps eliminate human "skill" — a necessary commodity that management has traditionally treated with relative respect. Instead of eliminating the worker, Shaiken suggests, why not give the machinist direct programming/editing capability, thus combining two useful, interesting, and highly productive skills?

☐ *Robots*. Previously billed as replacements for the tedious and undesirable jobs, robots are now beginning to take the desirable ones. In many cases, according to Mr. Shaiken, the worker and robot are treated interchangeably; and instead of using such technology to creatively complement worker "teams," management introduces robots as pace-quickeners. He described labor's prevalent image: one human worker flanked by two robots, with the person attempting to keep up with the machines much like Charlie Chaplin, in *Modern Times*, madly tightened bolts as the conveyor moved relentlessly on.

☐ *Factory management systems*. Using sophisticated monitoring techniques, management can determine the pace of workers throughout the factory and the day. Mr. Shaiken asserted that although such systems are introduced as information-gathering tools, their real purpose is to leave little or no discretion on pacing and time allocation to the workers themselves.

The threat to organized labor is clear and profound, he warned. Computer automation, as it is currently being applied, weakens unions at the bargaining table by eliminating their main weapon: the power to withhold labor. (Mr. Shaiken called this effect "technological scabbing.") And for the workers who remain in such a controlled, "player piano" environment, the chances for job satisfaction are increasingly remote. But computer automation is still in its earliest stages, and "the very flexibility of the technology can make it a positive force for labor and society. But for labor to be a beneficiary of the computer age, instead of its victim, labor must help in shaping it." — *S.J.M.* ☐

More Than a Paycheck

In the late 1960s, at one of those marathon political meetings at Harvard, the themes of the day were "exploitation and oppression" — of Americans in general and of the American worker in par-

ticular. As the debate became interminable, fruitless, and somewhat ill-informed, someone had the inspiring idea of actually consulting some workers. Climbing to the pulpit (literally — it was a meeting in Memorial Church), he scanned the hundreds of faces and entreated, "Where are the workers? Where are the workers?"

No one answered.

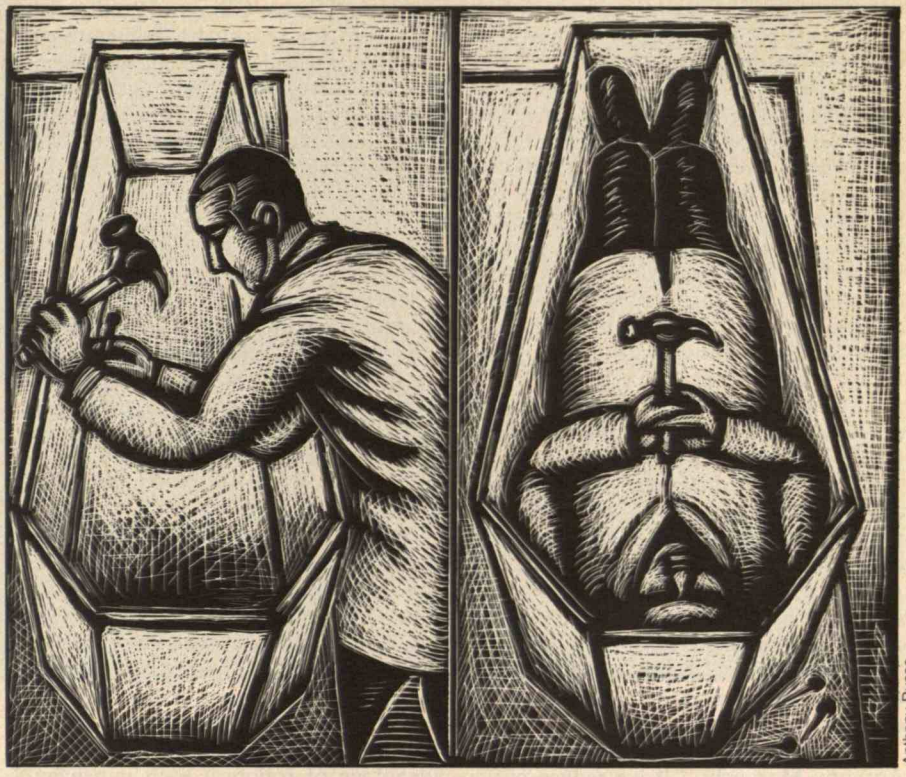
Finally, after several moments of embarrassed silence, we were all reminded why. A voice bellowed from the back: "They're at work."

Being at work may have saved some workers from boredom that day. But being at work does not save workers from other far more serious effects.

Today, therefore, many workers attend meetings on safety and health in the workplace. So do union officers, physicians, public health specialists, scientists (both physical and social), governmental regulators, journalists, and company spokespersons who claim to speak "the facts." Such a crowd attended a recent seminar sponsored by the Occupational Safety and Health Administration (O.S.H.A.) of the U.S. Department of Labor. O.S.H.A. entitled the meeting "Lost in the Workplace: Is There an Occupational Disease Epidemic?" and frankly intended to dramatize and publicize what one attendee termed "a national disgrace."

According to O.S.H.A.'s advance information: "It is estimated that at least 100,000 American lives are lost to occupational diseases each year, but no one knows the real toll, for this is a silent slaughter, a maelstrom lost amidst a maze of tongue-twisting chemicals, new industries, conflicting scientific reports, and government-industry debate. It is a story that usually surfaces only when disaster strikes, and even then it is often pictured as an extraordinary tragedy. Yet for millions of Americans, the daily threat to life and health is as real as it is constant; the payment for work is more than a paycheck."

Dr. Bertram Carnow, professor of occupational and environmental medicine at the University of Illinois, described the insidious nature of occupational disease: "For a long time, accidents held center stage with regard to worker safety. They are dramatic — a scream, a crunch of bone, blood, and the siren of an ambulance. Things are not quite so obvious with a disease that comes on with a cough or a wheeze. And the headaches, mild fatigue, and loss of weight are associated with other causes."



Anthony Russo

John Froines, deputy director of the National Institute for Occupational Safety and Health (N.I.O.S.H.), observed that the current emphasis on after-the-fact verification of cause-and-effect is immoral. Why not prevent the problem in the first place? Also, the subtleties of the process allow observers' expectations to influence their findings. "When you look for disease in the workplace," he said, "you'll find it. If you don't expect to find it, you won't." Dr. David Rall, director of the National Institute for Environmental Health Sciences emphasized the point: "It's better to prevent exposure to chemicals than to study human disease caused by chemicals."

But according to Mr. Froines and Anthony Mazzochi, vice president of the Oil, Chemical, and Atomic Workers' Union, industry's approach emphasizes treatment, not prevention. Dr. Bruce W. Karrh, corporate medical director of E.I. DuPont de Nemours Co., said that his firm "manages occupational health" principally with a formal program of "high-quality physical examination and medical surveillance" dating from 1915. Mr. Mazzochi observed that medical screening is certainly better than nothing, but programs based only on that practice reveal industry's basic attitude: "Don't address the problem; address the victim."

Most of the seminar's nonindustry speakers appeared to believe industry is pursuing a three-part strategy that makes matters even worse. First, industry denies the problem outright. Then it "puts it in perspective" (i.e., "assesses the risk"). Finally, industry makes as few at-the-source changes as possible.

Dr. Samuel Epstein (professor of occupational and environmental medicine at the University of Illinois) accused management of a long series of "Watergatisms" and white-collar crimes against worker safety and health [*see "Cancer, Inflation, and the Failure to Regulate," December/January, p. 42*]. Paul Brodeur, environmental writer for the *New Yorker*, minced no words when he advised the audience: "Don't follow the Neanderthals in industry who pervert Anglo-Saxon jurisprudence; 'innocent-until-proven-guilty' does not apply to chemicals." He applauded recent editorials in the *New York Times* and *Boston Globe* that called for criminal prosecution of delinquent company executives, and he suggested, for such cases, the use of Senator Howard Baker's famous Watergate question: "What did they know, and when did they know it?" Phil Lewis, producer of ABC-TV's award-winning documentary "Asbestos: The Way to Dusty Death," gave two pieces of advice to pro-labor inves-

tigators: get an attorney, and find a whistleblower "high enough to know and angry enough to help."

In rebuttal, most industry representatives asserted the unprovable — for example, that their own "3 to 5 per cent figure on cancer incidence due to occupational exposure is more accurate than the [O.S.H.A.] 38 per cent figure," and challenged O.S.H.A.'s rhetoric while providing their own: "There is no occupational disease epidemic, nor is there an epidemic of cancer in the U.S."; "the problems will be solved by scientists working cooperatively"; and "the real issue is 'acceptable risk.' Where should the line be drawn between government control and personal freedom?"

It is unusual (some might say refreshing, others disconcerting) for a federal agency to orchestrate an anti-industry media event. The O.S.H.A. and N.I.O.S.H. bureaucrats prefer to call their "bias" pro-worker rather than anti-industry. Said Dr. Anthony Robbins, director of N.I.O.S.H., "We are not 'neutral'; we work on behalf of the workers, trying to do what has to be done to make workers safe."

But safety does not come easily. Said Anthony Mazzochi, "If we reduce occupational exposure, we reduce productivity. Management and workers both understand this. It will cost. The question is: Who pays?" That the worker now pays was a repeated theme of the seminar. But no one said it as poignantly or as knowledgeably as Edward London, a former employee of National Lead Co. (now NL Industries) who had suffered from, but survived, lead poisoning. A wiry, white-bearded black man who spoke slowly and deliberately, but who could still manage a twinkle, Mr. London told us this: "I am a survivor. But if I had my life to live over again, I would not work in a factory that produces lead poisoning. It is hell, I must tell you. And the company did not care anything for the working class of people. I regret that time, and I regret the overtime — that was my life I was giving." — *S.J.M.* □

Exploding Population of Automatic Workers

The world population of robots used in industrial manufacturing is 17,500. Of these, 2,000 are in Europe, 2,500 in the U.S., and 13,000 in Japan.

Japan is "number one" in robot research, development, and utilization, says Professor Gustav Olling of Bradley University, as the result of a deliberate plan launched a decade ago. That was when a national survey of demographic trends revealed to the Japanese that their labor force would soon be inadequate to sustain the country's industrial aspirations. Accordingly, the government made major investments in research in manufacturing technology and set up a new infrastructure to bring industrial problems to these laboratories and to move the results efficiently back into industry. Now the Japanese are unique in the world in having set their sights on the "unmanned factory" and underwritten this goal with a $50 million research program on complex production systems which will combine individual "robots" into flexible manufacturing units.

Already the labor required in Japan to assemble a color television set is less than half that needed by the most efficient U.S. manufacturers before the industry moved across the Pacific. Matsushita Electric uses a central computer and four people to make vacuum cleaner parts that were formerly made by 120 workers. And the Japanese seek to capitalize on a unique advantage of robotics: each incremental unit of such a system — every individual automatic machine — returns dividends in reduced labor and increased efficiency that can be plowed back into research by which the individual machines will be interconnected as a fully automated factory.

U.S. production engineers who cited these achievements at the 1979 convention of the American Association for the Advancement of Science found Japan far ahead of the U.S. for two major reasons.

□ Most Japanese robotics rely on basic computer "hardware" and "software" pioneered in U.S. laboratories. An intense national spirit for industrial achievement, which seems to pervade the entire society — one speaker called it "Japan, Inc." — made possible the rapid application of these principles. Labor-management differences, consumer concerns, even environmental controversies seem to be subservient to this determination to achieve industrial goals.

□ About 70 companies in Japan are involved full-time in developing industrial robots; only six such firms exist in the U.S. and 33 in the Common Market countries of Western Europe. American firms put their capital in service enterprises where there are plenty of reassuring precedents for adequate return on investment, instead of turning to new robotics, said Professor Olling.

(*continued on page 80*)

Astronautics

Venus Unveiled

After almost two Venusian years of observation, *Pioneer-Venus 1* has provided history's first comprehensive look at the global surface of Venus. The outer skin, or lithosphere, of our cloud-shrouded neighbor turns out to be unlike that of Earth or any other planet.

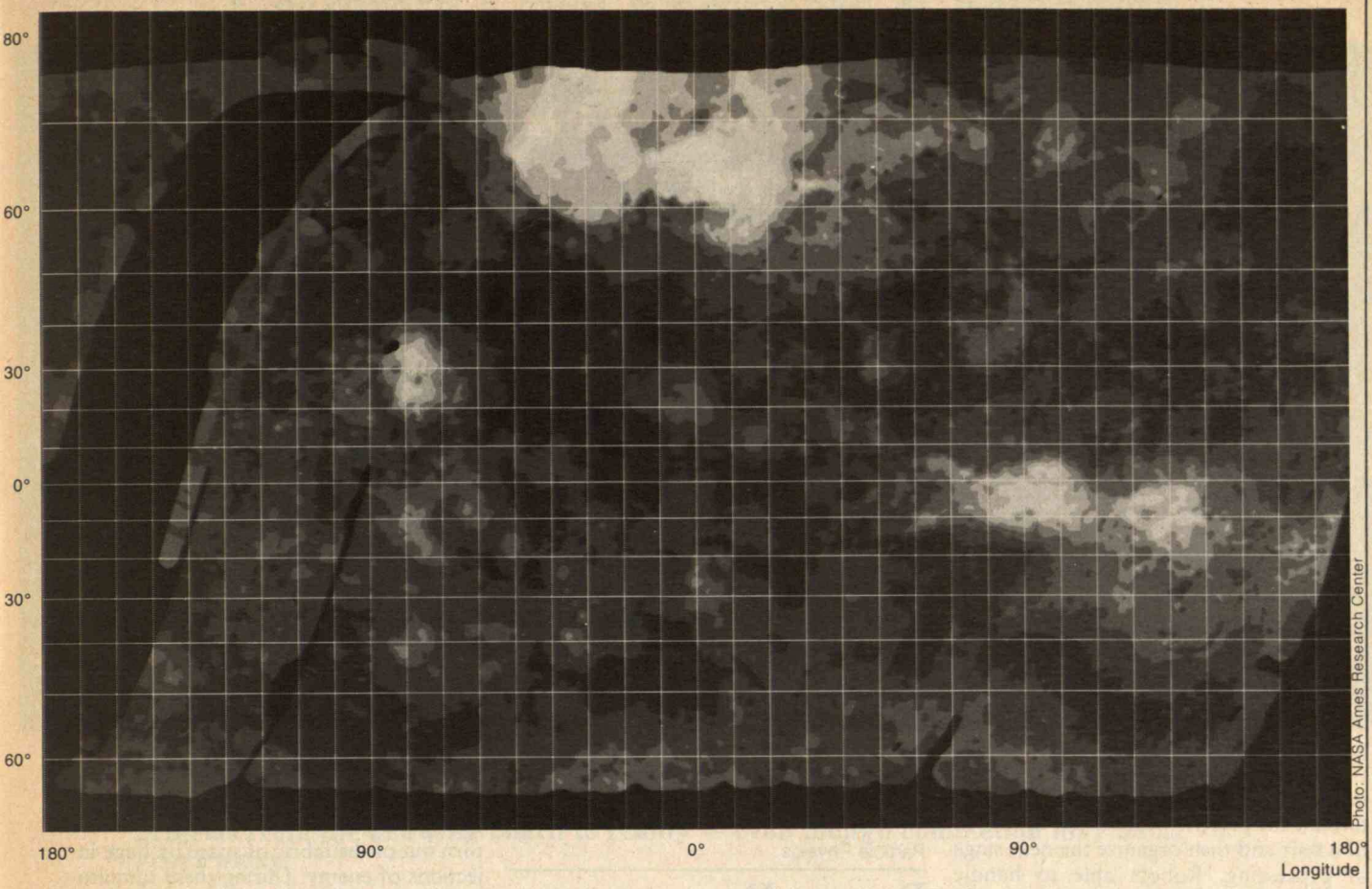
Despite her namesake, Venus stands revealed as the flattest world in the inner solar system. The crust of every other inner planet, including the Moon, shows considerable relief, owing to the presence of two major, disparate types of rock. Basalt, which is relatively dense, forms vast low plains, such as Earth's ocean basins and the Moon's maria; granite and anorthosite, which are less dense, form elevated continental regions.

Imagine the surprise of Gordon Pettengill, professor of planetary sciences at M.I.T. and team leader of the *Pioneer-Venus* radar mapper/altimeter experiments, when he found that Venus is almost entirely a lowland plain. The lowland extends uninterrupted for thousands of kilometers, covering 95 per cent of the mapped surface. He estimates that less than 5 per cent of the surface is elevated sufficiently to be considered continental; on Earth continents cover over 30 per cent of the surface. And at least two small regions, each about the size of Ohio, are depressed about one mile beneath the mean radius altitude.

Another surprise: the vast Venusian lowlands may not be basalt. The Soviet *Venera 8* lander found the radioactivity level of the Venusian lowlands to be the same as that of terrestrial granite.

Equally remarkable is the discovery that the Venusian lowlands, not the highlands, appear to contain craters. If the craters are the result of meteoric impacts, their shallowness would belie the presence of a weak planetary crust. And rough regions — possibly remnants of material hurled out by impacts — outside some of the circular features interpreted as craters were recently reported by Barbara Burns of Cornell University. But these apparent ejecta seem to extend farther from the assumed area of impact than the existing relief would suggest should be the case. If crustal flow occurred after the craters were formed, this puzzle would be solved.

Alternatively, it has been suggested that the extremely high temperatures at the planet's surface could have weakened or even melted crustal rock, thus diminishing relief. This hypothesis is suspect because water is extremely scarce on Venus; the absence of water raises the melting tem-



The first contour map of Venus. The contour interval is one kilometer of elevation, represented by values of gray, and black: the black areas are the lowest (except for the broad gap at the left and small intrusions at the bottom, which result from missing data); the white areas are the highest. The black areas represent a value of planetary radius between 6,049 and 6,050 km. and the brightest correspond to radii greater than 6,058 km. Small regions in the mountains at the top center rise to 6,062 km. from the center of the planet. This map, a Mercator projection, exaggerates the areas of high latitude: the upland area near the equator at longitude 80° to 150° is in fact as large as that nearer the pole of the planet between longitude 290° and 60°. Gaps in data filled during future orbits of *Pioneer-Venus* will be added to this remarkable detail of 83 per cent of the planet's total surface — *Gordon Pettingill* □

perature of a given mineral, and one could reasonably expect rocks composed of such minerals to be especially resistant to thermal insults.

Three highlands give dramatic relief to the monotony of the Venusian plains; they stand several miles above the plain, have well-defined boundaries, and are probably made of rock quite different from that of the lowland plain.

One of these, the Regio Beta, may be basalt, a speculation consistent with the low levels of radioactivity detected by *Venera 9* and *Venera 10*, which landed on its eastern flank. At this time, the composition of the two other highlands, Terra Ishtar and Terra Aphrodite, is anyone's guess. If the lowland really is granite, the highland rock should be even less dense. But on other planets such material doesn't exist in the relative abundance needed to make continents.

Two huge features, seen but not understood in previous, Earth-based mapping, dominate Terra Ishtar, a continental mass about the size of Australia. One, a great pear-shaped plateau called Planum Lakshmi, is bigger and higher than any plateau on Earth. According to Harold Masursky, geologist with the U.S. Geological Survey, it was uplifted with relatively little horizontal motion. A similar process was involved in the formation of all the major plateaus on Earth.

Two great mountain ranges can be seen to the northeast and west of Planum Lakshmi. They are thought to be huge blocks bounded by faults, presumably formed when Planum Lakshmi was uplifted (the Rockies are an example of such "fault-block mountains" on Earth). Or, they may be "fold mountains" formed by compressional pressures in the planet's crust, like the Appalachians and the Alps.

At the eastern end of Terra Ishtar is Montes Maxwell, the roughest and hence most radar-reflective region on Venus, standing over 35,000 feet above the lowland plain. Great mountains on Earth are associated with slightly greater gravitational pull than lowlands, but data taken above Montes Maxwell show no such gravity anomaly.

Regio Beta, the third highland, turns out to be a pair of major shield volcanoes (so-called because they resemble low, expansive shields of rock) rising along a fault zone from a plateau about 1,000 miles long. Conspicuously missing from the map, however, are the extensive flat sheets typically formed by basalt flows on Earth, the Moon, Mars, and Mercury; examples include the lunar maria and the Snake River Plateau in Idaho. One speculation is that the water-poor Venusian flows were more viscous than other basalts and maintained their relief even at greater distances from the vent.

Many observers are astonished that the relatively crude *Pioneer-Venus 1* radar — almost an afterthought on a mission designed primarily to study the planet's atmosphere — has achieved such far-reaching results. The next step, planetologists hope, is VOIR (Venus Orbiting Imaging Radar). The resolution of VOIR radar will be two or three orders of magnitude better than that of *Pioneer-Venus 1*. But that vision is for the future. — *Jim Loudon* □

There is no lack of opportunity for automatic manufacturing technology in the U.S. Most large U.S. industries with high-volume product lines are well automated; Paul F. Chenea, a vice president of General Motors Corp., has said that G.M. is working on robots with "television eyes" to inspect parts, and on automatic assembly machines for production lines. But Professor Olling, who made the census of world robots which opens this piece, points out that 75 per cent of U.S. output is produced by batch methods; and in the metalworking industries many batches are lots of no more than 50 identical pieces. In such a workshop, a piece of stock may be on a metalworking machine for as little as 5 per cent of the time, and only 30 per cent of the time on a machine is actually devoted to metal cutting. Efficient, automatic control of machine tools could raise both figures to close to 90 per cent.

Sophisticated, computer-linked robots are required; they have to be able to determine the present location and condition of a part and then organize the next stage of processing. Robots able to handle "batch" processing jobs must be capable of dealing with many different shapes and kinds of materials. But they do exist; Professor Olling described machines that can "pick up, place, position, push, pull, turn, weld, spray, rivet, sand, grind, and rout" — performing work in "seven axes of arm or hand articulation" on pieces traveling along continuously moving conveyors.

But more remains to be done. "The use of data from touch, force, proximity, vibrations, temperature, and visual sensors to modify system behavior in response to irregularities, uncertainties, and unexpected events is a complex problem," said Professor Olling, and "well-established engineering procedures" are lacking. These are problems for the discipline called "artificial intelligence."

Then, too, there are materials problems. Since World War II a vast new science of metals — dislocation theory, phase transformations, brittle fracture and fatigue — has grown to maturity. But practical applications of these advances are not simple; materials problems in manufacturing are "messy and multidimensional," said Professor George E. Dieter of the University of Maryland, who listed a score of interface, plastic flow, deformation, and other phenomena on which adequate research is lacking. Ten years of research will be needed for materials scientists to develop "a scientific base for enhanced productivity."

Increasing automation also raises problems for the human operators of the robots which will do the job. John W. Bernard, director of research for the Foxboro Company, put it this way: "In the early years of this century, an industrial control room operator was in direct contact with the process which was his responsibility. However, with the advent of automation, the man in 'control' becomes less involved with the process. Sometimes a cathode ray tube is the only 'window' available, and sometimes this 'window' is not adequate.

"We haven't really taken advantage of the other human senses — hearing, smell, touch, perhaps even taste — to give a better comprehension of conditions within the process plant," said Mr. Bernard, and he thinks this goal of "improving human abilities to cope with ever more complex industrial operations" is "one of the imperatives facing researchers today." — *J.M.* □

Particle Physics

Proton Decay: A Shot in the Dark?

Protons have long been a physicist's best friend — like diamonds, they are supposed to be forever. But recent advances in theoretical physics — such as the ones that earned the 1979 Nobel prize in physics — have eroded the long-cherished, intuitively acceptable belief that protons are among the stablest of all known forms of matter.

Physicists based their confidence in the longevity of protons on the "law of baryon conservation," or "conservation of baryon number." Protons, which are baryons (and have a baryon number of one), shouldn't just vanish in a burst of radiant energy, leaving no baryons behind.

But the law of baryon conservation also created some problems. It implied that there must be equal amounts of matter and antimatter in the universe — but if this were true, mutual annihilations of matter and antimatter would long ago have reduced the cosmos to a rubble of light. This reasoning follows from the now-favored "big bang" theory, which holds that protons were forged from a blob of pure energy, and that for each proton an antiproton (with a baryon number of minus one) should also have been created to conserve baryon number. This relationship is called matter-antimatter symmetry, and it creates a peculiar puzzle, according to Lawrence Sulak, professor of physics at the University of Michigan: "Why *are* we this contamination in the universe?"

Some scientists have devised fancy — and mostly fanciful — schemes to save matter-antimatter symmetry while accounting for our existence. For example, large chunks of protons and antiprotons are proposed somehow to separate into isolated and insulated regions of space to form a kind of yin-yang universe. But despite exhaustive searches, no one has found conclusive evidence for antiworlds. (We are, on the other hand, reasonably sure that we exist.)

As it turns out, all the currently acceptable theories about the underlying structure of matter — the so-called "grand unified theories" — give us a way out of this bind: abandon the notion of matter-antimatter symmetry at the gargantuan energy levels that existed during the Big Bang. Incredibly large forces may have been produced as particles of matter were torn out of the fabric of space by huge injections of energy. During these tumultuous moments Nature might have shown a preference for creating just protons instead of protons and antiprotons in pairs, so that in the end protons outnumbered antiprotons. Eventually, most of the antimatter would have been annihilated during encounters with matter, leaving a residue of . . . matter.

But how is such a theory tested? "The only window we have on all this physics is to find out whether [conservation of] baryon number is slightly violated," says Leonard Susskind, professor of physics at Stanford University.

An unusual and pleasingly simple experiment designed by Professor Sulak and his colleagues may open just such a window. Ten thousand tons of ultra-pure water, filling a tank the size of the Lincoln Memorial, would be placed half a kilometer underground in an Ohio salt mine to shield it from "noisy" cosmic ray bombardment. Several thousand submerged photomultiplier tubes would be on the lookout for telltale bursts of light — sure signs, Professor Sulak says, of decaying protons.

This approach could raise the lower limit on proton lifetime (currently assumed to be 10^{30} years) by a factor of 100,000, say its progenitors, emphasizing that the observation of proton decay would be a truly monumental discovery.

The concept is certainly no shot in the dark: three Nobel laureates in physics,

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Steven Weinberg, Sheldon Glashow, and Abdus Salan, have noted the importance of the $2-million experiment. Professor Weinberg says that he would be very surprised if proton decays were not found. "Baryon number ought to be violated," agrees Professor Susskind. "It has to be, if any of the current ideas are right." — *June Kinoshita* ☐

Pollution

Cooling the Fires Under Solid Waste

Somewhere near Washington, D.C., is a pile of 1,300 tons of pellets of d-RDF — densified, refuse-derived fuel. The pellets contain the combustible fraction of municipal solid waste which has been shredded, partially dried, and carefully compacted by a machine not unlike that which extrudes pellets of dog food.

Each pellet of d-RDF is about the size of a roll of coins — half an inch in diameter and an inch or two long. Designed to go into a boiler as a substitute for (or supplement to) stoker coal, the pellets yield some 7,500 B.t.u.'s per pound.

But despite their energy content, the rising cost of conventional fuel, and the considerable technology that went into the National Center for Resource Recovery's process to create them, the pellets remain stockpiled — a symbol, perhaps, of the uncertainty that still surrounds the burning of discarded household waste to obtain useful heat.

Proposals and processes to utilize the pellets abound. But, at least in the United States, the technology remains immature. Here's a summary of several reports presented during the American Chemical Society's fall 1979 meeting:

☐ The first electric generating plant in the United States to be fueled with municipal solid waste — in St. Louis, Mo. — proved the need for "a great deal of work" on the equipment and for optimizing the process, said Donald K. Walter, chief of the Department of Energy's Urban Wastes and Municipal Systems Division.

☐ Pelletized d-RDF "has not yet been proven commercially, and the costs and firing characteristics are yet to be evaluated," reported Mr. Walter.

☐ A new process for powdering solid waste into a fuel that can be cofired with coal seems promising, as do a lot of other new processes. But "the dustlike composition" of the fuel "necessitates special handling to minimize the danger of explosion."

☐ In all, seven plants designed to generate steam through burning solid waste are now in operation in the U.S.; each is experiencing corrosion, erosion, and/or emissions problems.

☐ Some 430 facilities worldwide are now engaged in converting municipal, commercial, and light industrial waste into useful energy. Why is the United States so far behind? A simple answer is given by Philip R. Beltz of Battelle Columbus Laboratories, who completed a survey for the U.S. Environmental Protection Agency: people in Europe, where most of these plants are located, "are more concerned with the harmful effects of landfills."

In general, said Dr. Beltz, *net* operating costs of European systems producing energy from waste are two to four times the costs of maintaining landfills accommodating comparable amounts of waste. This difference is probably even greater in the United States, where few communities using landfill disposals charge themselves the full cost. As a result, said Dr. Walter, U.S. energy recovery sytems are handicapped not only by unfavorable economics but by the inability to acquire raw material — i.e., urban waste.

But while some members of the A.C.S. Division of Environmental Chemistry were lamenting the slow course of RDF technology, others in the next room were hearing a very different story. Environmental constraints, rather than municipal economics, may be the downfall of RDF combustion: while usually devoid of sulfur, RDF may include other materials whose release into the atmosphere is undesirable and even illegal.

☐ Christoffer Rappe of the University of Umea, Sweden, and Hans-Rudolf Buser of the Swiss Federal Research Station at Wadenswil have found PCDDs and PCDFs in the fly ash and flue gas of municipal and industrial incinerators. Some of these fractions of chlorinated phenols, phenoxy acids, and PCBs are "extremely hazardous," they warned.

☐ Thomas J. Murphy of DePaul University regularly finds PCBs in the atmosphere above the Great Lakes, and as much as 1.5 tons a year may fall into Lake Huron alone each year. Similar studies by S. J. Eisenreich and G. J. Hollod of the University of Minnesota show nearly two tons of PCBs entering Lake Superior annually. Professor Murphy speculates that municipal incinerators are among the major sources. — *J.M.* ☐

Innovation

Old Script, New Actors

A two-year outpouring of reports on innovation and how to foster it has climaxed in President Jimmy Carter's message to Congress distilling (and in many cases excising) recommendations of a Domestic Policy Review. The review was itself the climactic effort of countless U.S. innovation groups — a very few of whom were also innovators.

Meanwhile, most indices suggest that innovation and its offspring, productivity, have continued the decrease that stimulated the outpouring in the first place. A joke at the National Academy of Engineering December colloquium in Washington, D.C.: better days may be ahead *if* the president's message to Congress ends the nation's compulsion to study the subject . . . so that the innovators can return to their innovation.

No one seriously embraced that explanation for the decline of innovation. Nor was there optimism that the Domestic Policy Review and its outfalls could have a stunningly positive effect on the worrisome trend. Two problems plague the innovation process: Innovation is diffuse, abstract, and — despite all those studies — not really well understood; it's therefore a frustrating subject for policymaking. In addition, innovation is linked to the economy in a complex system of loops that feature what engineers call inverse feedback. N. Bruce Hannay, vice-president of Bell Telephone Laboratories, offered some examples of such loops to explain policymakers' difficulties:

☐ Inflation is clearly the enemy of entrepreneurship — when potential investors can make 12 per cent on their money in special savings accounts, no risky invention can be very appealing without promising a much greater return. But successful innovation is the key to increasing productivity, which in turn is the key to reducing inflation.

☐ Competition in a healthy economic environment breeds innovation, but innovation can weaken, distort, or even eliminate competition.

☐ Much innovation is aimed at reducing the cost of production, often by reducing the labor required to make a product; thus innovation may increase unemployment, and that drives the economy downward.

It's hard to know where to intervene in

Continued on page 84

Last Line

Sin of The Fathers

Mel Williges

Edward Teller is a man of "jovial and happy temperament"; Hans Bethe is "not only a great physicist but an outstanding trainer of students" (who call him Hans); the late Robert Oppenheimer was "Oppy"; and Richard Feynman is known for "his loud voice, his quick mind, his intense interest in all kinds of things and people, his crazy jokes, and his disrespect for authority." Thus does physicist Freeman Dyson describe the developers of the atomic bomb — its "fathers," in popular phraseology — in *Disturbing the Universe*, his clear and sensitive memoir.

Hardly cold-blooded scientist types from Central Casting, these men were nevertheless those to whom Oppenheimer referred when he uttered the famous confession: "In some sort of crude sense which no vulgarity, no humor, no overstatement can quite extinguish, the physicists have known sin; and this is a knowledge they cannot lose."

Participation in such a project ("the perfection of engines of destruction even more fiendish than those that mankind already possessed," in Dyson's words) clearly involves individual acts: serving one's country by expressly helping to make it mighty; or, perhaps more current at the time, functioning as a scientist — doing one's own thing — and leaving the actual choices to political and military leaders. This ultimate example of the scientist's responsibility (or lack thereof) has been debated ever since "the Los Alamos people," as Dyson calls them, accomplished their goal. But he adds another dimension. The sin, Dyson maintains, was not so much in individual decisions; it arose from the group process — "the ethos of engineering."

In Dyson's experience, engineering projects are collective efforts "based on teamwork rather than personal competitiveness. . . . There are no prima donnas in engineering." Working on Project Orion (an abortive, late-1950s program to build nuclear-powered spacecraft), for example, he observed that "it did not matter who invented what. The only thing that mattered was that the final product of our inventions should function reliably."

Dyson met "the Los Alamos people" immediately after the war at Cornell University, where he had come to do graduate work. Although most were scientists (as opposed to engineers), they had just collectively accomplished one of the great technical feats of all time, and they were ecstatic. "There was endless talk about the Los Alamos days. Through all the talk shone a glow of pride and nostalgia. For every one of these people, the Los Alamos days had been a great experience — a time of hard work and comradeship and deep happiness. I had the impression that the main reason they were glad to be at Cornell was that the Cornell Physics Department retained something of the Los Alamos atmosphere. I, too, could feel this atmosphere — it was a vivid presence. It was youth, it was exuberance, it was informality, it was a shared ambition to do great things together in science without any personal jealousies or squabbles over credit."

And herein, strangely enough, lies the sin. The irreversible horror of the bomb seems to have been, if not forgotten, at least conveniently overlooked amidst the joys of professional and personal camaraderie, the satisfaction in meeting an incredibly difficult challenge, and the pride in coming to the aid of one's country. Says Dyson: "The sin of the physicists at Los Alamos did not lie in their having built a lethal weapon. To have built the bomb, when their country was engaged in a desperate war against Hitler's Germany, was morally justifiable. But they did not just build the bomb. They enjoyed building it. They had the time of their lives while they were building it. That, I believe, is what Oppy had in mind when he said they had sinned. And he was right." — *S.J.M.* ☐

such relationships, and the points of intervention are as much political as intellectual issues. In some sense at least, the innovation issue simply provides a new pleading ground for the same old arguments about tax reform, tax loopholes, government intervention, incentives, etc.

There are a few issues on which everyone can agree. To stimulate innovation, the U.S. must improve communications about technology, must provide economic and political stability and predictability, and must provide an atmosphere of trust and respect between innovators and users of innovations. Without the latter, isn't declining innovation a self-sustaining trend?

Everyone wants the Patent Office to speed and improve its handling of applications, its enforcement of existing rights, and its protection for such new intangibles as computer programs and the organisms designed by recombinant DNA technology. But there is inverse feedback even here: almost everyone agrees that patents stemming from government-sponsored research should be made widely available to would-be entrepreneurs; but this requirement, which aims at wide dissemination and use of an innovator's work, may compromise the opportunity for personal gain from it — and so weaken the incentive for future innovation.

Some hold that innovation results from research and development. But should such efforts be financed by government or by industry (with the bill sweetened a little by tax incentives)? Should research concentrate on basic science or technology? (Walter S. Owen, head of the Department of Materials Science and Engineering at M.I.T., made an eloquent plea for a "national engineering foundation" to give technology the same strong support that science has had from the National Science Foundation, but others argued that science has to found technology and NSF has made a proper balance.)

Most studies show that small firms are more innovative than big ones, so there is a lot of bargaining for special incentives and privileges for small businesses. But Ralph Landau, chairman of Halcon International, Inc., was uncomfortable with such conclusions: only large organizations can take large risks, he said, and some of our most successful innovations have involved very large risk taking — new pharmaceuticals, for example.

What about regulation? It's conventional wisdom that government regulation is the enemy of productivity, committing vast capital resources to goals on which the marketplace is at best ambivalent. From this it follows that innovation resulting from regulation is not true innovation, for it makes little or no contribution to measurable economic growth. This conventional wisdom led the NAE colloquium to resonate with various proposals to soften the impact of any environmental health or safety regulation that has a "punitive" effect on an innovative enterprise.

How does Congress look at all this? Innovation — at least in terms such as these — is "not yet an issue of high visibility," said John D. Holmfeld of the House Subcommittee on Science, Research, and Technology — "not a 'class-A-type' problem." However, there may be some helpful changes underway: funding for small-business centers in colleges and universities, tax incentives for industries making research grants to universities and nonprofit institutions, some funding for generic research efforts. But many legislators tend to see the issue in terms of the same tired economic arguments they're used to hearing from trade associations, chambers of commerce, and professional societies. Said Stephen Merrill of the Senate Subcommittee on Science, Technology, and Space: "After 20 years our perception of productivity and the forces affecting it has hardly changed. . . . I sense that Congress isn't really interested in old arguments about innovation."

However, innovation itself is alive and well in (where else?) California. Vincent J. Roggeveen, a "Silicon Valley" transportation consultant, said he sees examples of a new kind of innovation in the vans, hot rods, surfboards, and other technologies of the counterculture. And, he quipped, it takes real innovation to outwit the forces of law and order to turn marijuana into California's largest cash crop. — *J.M.* □

Books/Continued from page 18

have tended to be elementary, directed toward high-school students and lower-division college students. Textbooks for college juniors and seniors, graduate students, or practicing engineers have focused on the description of specific chemical industries, engineering science, the design and control of specific types of chemical plant equipment, and optimization based on economics. Wei, Russell, and Swartzlander are the first to write a text intended to present chemical engineering as a profession whose lofty ideas and intellectual demands can rival those of such professions as medicine or law.

The goal of broadening minds requires a thoughtful plan — sensitive, imaginative, well-executed. In presenting their subject, the structure of the chemical-processing industries, the authors write as if they were architects. Emphasis is placed on how organizers, designers, and artisans relate form to the surrounding landscape, the physical, mental, and emotional needs of users and neighbors, available materials and methods of construction, legal concerns, financing, and future developments. In short, the authors intend that students appreciate the genius as well as the flaws, both technical and humane, of a structure as if it were a masterpiece of architecture.

One of the book's contributions may endure for millennia. Every profession needs a symbol to remind both its members and the public of its service ideal. Medicine has the staff of Aesculapius, the Greek god of healing. The legal profession has Justitia, the blindfolded Roman goddess holding a balance. But engineers have never had such an emblem. Who knows? Perhaps from now on, the engineering profession, whose international language, mathematics, depends so heavily on the use of Arabic numerals, will have for its symbol that figure from the Arab heritage — a Grand Vizier offering a carpet with wings.

This book should cause members of the other branches of engineering to ask themselves, "Has such a book been written for students of our branch? If not, what are we going to do about it?"

H. Clay Lewis is professor of chemical engineering at Georgia Institute of Technology. □

Solution to December/January Crostic

The major* effect of an air-cushion vehicle moving over water is to depress the water surface under (it). If the vehicle, serving as an icebreaker, is made to advance from water toward an ice sheet, the water is forced away and the unsupported ice crumbles of its own weight. The concept has been tested by the Canadian Coast Guard.

*inserted

John Mattill, "(Technology for) The Arctic Oil Rush," TECHNOLOGY REVIEW, Mar./Apr. 1979

A. Jespersen	O. Abracadabra
B. Offbeat	P. Reigned
C. Hugh the Drover	Q. Cowcatcher
D. Neff's Cave	R. Two times two
E. Mad Mathesis	S. Irrawaddy
F. Akhenaten	T. Conscientious scientist
G. Teshumai Tewindrow	U. Obrecht
H. Tennstedt	V. Icosahedron
I. Invective	W. Lafcadio Hearn
J. Lecture	X. Regge
K. Lode	Y. Up to snuff
L. Typeface	Z. Sweetwater
M. Heteromi	Z_1. Havasupai
N. Echeverria	

Found: First Double Quasar

Images of 0957 + 561 A and B were first obtained in March, 1979, at Kitt Peak National Observatory by a team of University of Arizona astronomers. But the pictures were far from clear, and the astronomers concluded that they might have two pictures of a single object instead of a single image of two objects.

But there really *were* two objects, and the picture was probably of the first double quasar ever observed. That conclusion comes from a team of M.I.T. astronomers on the basis of their radio observations from the National Radio Astronomy Observatory near Socorro, N. Mex.: 0957 + 561 A and B show up on their radio map as two point-like images, with one of which is associated a powerful, extended radio source.

The double quasar lying deep in the fringes of the universe is their "favorite interpretation"; partly, that's because any single object radiating what they detected from 0957 + 561 would have to be 100 times as massive as any galaxy yet observed — "a dramatic new class of objects." □

Restoring the Federal Government-University Partnership

University-government relations, seriously strained in the mid-1970s, seem to be on the mend.

"During the past year a more meaningful dialogue was conducted between the universities and the federal government than at any prior time in this decade," write Jerome B. Wiesner and Paul E. Gray, president and chancellor, respectively, of M.I.T., in their annual report to the Institute's Corporation. "Both (universities and government) have developed a far deeper understanding of the attitudes and problems of the other," they write.

Drs. Wiesner and Gray cited several issues over which the university-government partnership seemed to be foundering:

□ Principles governing federal reimbursement of research costs. The emphasis on "fiscal accountability" had threatened "a relationship in which universities would be regarded as vendor essentially indistinguishable from commercial organizations."

□ Restrictions on faculty salaries charged to grants from the National Science Foundation. There were "enormous and disturbing . . . implications in terms of federal involvement in the internal policies of universities."

□ The decrease in discretionary funds as project-by-project funding is emphasized. "We have suggested that regular provision of funds for the support of independent research would . . . help preserve the dynamism and freedom of inquiry (of) major research universities."

Encouraged by the interaction between government and the universities in 1978-79, Drs. Wiesner and Gray conclude that "problems with the relationship are in large part the result of misunderstanding, inadvertence, and inattention of the kind that can result in any relationship taken too much for granted." □

Summer Short Courses

Sixty-three short courses in advanced and specialized subjects in technology and related social sciences will be given at M.I.T. during the summer of 1980. Tuition, depending on the length and subject of the course, ranges from $450 to $1,350, not including meals and housing which are available on the campus.

The following list shows the title, director, and dates of each course; for further information, write to the Director of the Summer Session, Room E19-356, M.I.T., Cambridge, Mass. 02139.

Chemical Engineering:
Modeling, Simulation, and Optimization of Chemical Processes, Professor Lawrence B. Evans, July 21-30.
Rheological Behavior of Polymeric Fluids, Professor Robert E. Cohen, July 28-August 1.
Computer Science:
Designing Microprocessor-Based Systems, Professor Francis F. Lee, June 16-27.
Design and Implementation of Modular Software, Professor John V. Guttag, June 23-27.
Data Flow Concepts in Computer Language and Architecture, Professor Jack B. Dennis, June 16-20.
Project Design for EDP Applications, Professor Robert M. Alloway, June 23-27.
Information Systems Technologies, Professors John J. Donovan and Stuart E. Madnick, August 18-22.
Techniques of Computer Sound Synthesis, Professor Barry L. Vercoe, June 16-27.
Computer Music Composition Workshop, Professor Barry L. Vercoe, June 30-August 4.
Electrical Engineering:
High-Speed Photography and Videography, Charles E. Miller, June 9-13.
Modern Control Theory Methods for Deterministic Systems, Professor Michael Athans, July 21-25.
Modern Control Theory Methods for Stochastic Systems, July 28-August 1.
Advanced Topics in Modern Control Theory, Professor Michael Athans, August 4-8.
Digital Speech Processing, Victor W. Zue, June 23-28.
Energy:
Solar Energy Systems, Professor Richard D. Thornton, July 14-18.
Superconducting Magnet Design, Alberta M. Dawson, June 23-27.
Materials Science:
Ceramics Processing, Professors H. Kent Bowen and Robert L. Coble, June 16-20.
Corrosion, Professors Ronald M. Latanision and Gregory J. Yurek, July 7-11.
Nuclear Engineering:
Man-Machine Interfacing in Nuclear Power and Industrial Process Control, Professors Thomas B. Sheridan and David D. Lanning, June 23-27.
Nuclear Power Reactor Safety, Professors Neil E. Todreas and Norman C. Rasmussen, July 7-11 and July 14-18.
Ocean Engineering:
Analysis of Welded Structures, Professor Koichi Masubuchi, August 11-15.
Port Management and Operations, Professor Ernst G. Frankel, August 11-15.
Port Planning and Design, Professor Ernst G. Frankel, August 18-22.
Use of Computer Programs in Naval Architecture, Professor Chryssostomos Chryssostomidis, June 16-20.
Use of Computer Programs in Ocean Engineering, Professor Chryssostomidis, June 23-27.
Transportation:
Transportation Systems Management, Professor Marvin L. Manheim, August 4-8 and August 11-15.
Urban Transportation, Professor Marvin L. Manheim, August 4-8 and August 11-15.
Freight Transportation, Professor Paul O. Roberts, August 4-8 and August 11-15.
Forecasting Transportation Demand, Professor Moshe E. Ben-Akiva, August 4-8, August 11-15, and August 18-22.
Transportation in Developing Countries, Professors Marvin L. Manheim and Richard M. Soberman, August 4-15.
Transportation Networks Analysis, Professor Yosef Sheffii, August 13-15.
Health and Safety:
Radiation Hazards in Medicine and Industry, Professor Padmakar P. Lele, August 18-22.
Techniques and Principles in Toxicology and Pathology, Professor Paul M. Newberne, August 11-15.
Engineering and Applied Science:
Aerial and Marine Screw Propellers, Professor E. Eugene Larrabee, July 7-11.
Lasers and Optics for Applications, Professor Shaoul Ezekiel, July 14-25.
Nutrition and Food Science:
Polymers in Medicine, Food, and Agriculture, Professor Robert S. Langer, Jr., August 4-8.
Fermentation Technology, Professor Daniel I. C. Wang, July 28-August 1.
Advances in Food Science and Technology, Professor Marcus Karel, July 21-25.
Advances in Food and Applied Microbiology, Professor Anthony J. Sinksey, August 4-8.
Food Rheology, Professor Chokyun Rha, July 28-August 1.
International Food and Nutrition Policies, Professor Mitchell B. Wallerstein, July 21-25.
Decision Analysis and Operations Research:
Risk Assessment and Insurance Regulation, Professors Joseph Ferreira, Jr., and William H. DuMouchel, August 4-8.
Design and Analysis of Scientific Experiments, Professor Harold Freeman, June 23-28.
Public Program Evaluation, Professor Richard C. Larson, August 11-15.
Decision Analysis, Professor Alvin C. Drake, August 11-15.
Decision Analysis with Multiple Objectives, Professor Alvin C. Drake, August 18-22.
Market Research:
Forecasting Market Shares, Professor Yosef Sheffi, August 18-22.

Finance and Investment:
Models for Financial Management and Planning, Professor Stewart C. Myers, July 21-25.
Modern Concepts in Financial Management, Professor Steward C. Myers, July 14-18.
Management:
The System Dynamics Approach to Corporate and Economic Policy, Professor John D. W. Morecroft, June 9-20.
Management Control Systems, J. Morris McInnes and Professor Michael F. van Breda, June 16-20.
Strategic Planning Systems, Professors Arnoldo C. Hax and Michael S. Scott-Morton, June 23-27.
Production and Distribution Management, Professor Arnoldo C. Hax, July 14-18.
Dynamics of Health Service Systems, Professor Edward B. Roberts, August 11-15.
Management of Research, Development, and Innovation, Professor Edward B. Roberts, June 9-20.
Corporate Strategy and Policy, Professor Zenon S. Zannetos, June 9-13.
Facilities Management Systems, Kreon L. Cyros, June 23-27.
Energy Planning Models, Professor Jeremy F. Shapiro, July 28-August 1.
Resource Management, Professor Jeremy F. Shapiro, July 14-18.
Psychology
Problem-Solving in Human Systems, Professor Stephan Chorover, June 16-20.
International Affairs:
Corporate and Investment Strategies for South Africa, Professor Robert I. Rotberg, June 9-12.
Technical Writing and Editing:
Communicating Technical Information, Professors James Paradis and Robert R. Rathbone, August 4-8.
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What Can You Make From 'Energy'?

Most people think of "energy" as gasoline for their cars or heat for their homes. But 4.5 percent of the nation's oil and natural gas is used by companies like Union Carbide as a petrochemical raw material: every one of the products listed here and thousands more are made from petrochemicals.

- ☐ Credit cards
- ☐ American flags
- ☐ Eyelashes
- ☐ Aspirin
- ☐ No-wax floors
- ☐ Permanent-press clothes
- ☐ Oxygen masks
- ☐ Golf balls
- ☐ Ink
- ☐ Lighter fluid
- ☐ Heart valves
- ☐ Hair spray
- ☐ Attache cases
- ☐ Crayons
- ☐ Steering wheels
- ☐ Wet suits
- ☐ Disposable diapers
- ☐ Food wraps
- ☐ Laxatives
- ☐ Parachutes
- ☐ Stretch pants
- ☐ Trash cans
- ☐ Telephones
- ☐ Rubber duckies
- ☐ Brassieres
- ☐ Enamel
- ☐ Seed tape
- ☐ Wall coverings
- ☐ Transparent tape
- ☐ Card tables
- ☐ Acrylic paints
- ☐ Antiseptics
- ☐ Golf cart bodies
- ☐ Vacuum bottles
- ☐ Vinyl siding
- ☐ Slips
- ☐ Shoe trees
- ☐ Safety flares
- ☐ Warm-up suits
- ☐ Bearing grease
- ☐ Overcoats
- ☐ Ping-pong paddles
- ☐ Rafts
- ☐ Bubble bath
- ☐ Purses
- ☐ Sockets
- ☐ Bookends
- ☐ Weed killers
- ☐ Flippers
- ☐ Planters
- ☐ Football pads
- ☐ Tiles
- ☐ Deodorant
- ☐ Puzzles
- ☐ Air conditioners
- ☐ Panty hose
- ☐ Backpacks
- ☐ Bathinettes
- ☐ Records
- ☐ Typewriter ribbons
- ☐ Footballs
- ☐ Disposable lighters
- ☐ Doorknobs
- ☐ Upholstery
- ☐ Uniforms
- ☐ Phonographs
- ☐ Hearing aids
- ☐ Welcome mats
- ☐ Car sound insulation
- ☐ Racks
- ☐ Pacifiers
- ☐ Dresses
- ☐ Cassettes
- ☐ Garment bags
- ☐ Track shoes
- ☐ Dominoes
- ☐ Fences
- ☐ Car polishers
- ☐ Luggage
- ☐ Kitchen counter tops
- ☐ Protractors
- ☐ Antifreeze
- ☐ Earphones
- ☐ Flashlights
- ☐ Windbreakers
- ☐ Whistles
- ☐ Motorcycle helmets
- ☐ Pillows
- ☐ Clothesline
- ☐ Dune buggy bodies
- ☐ Carpet sweepers
- ☐ Antibiotics
- ☐ Checkers
- ☐ Chess boards
- ☐ Shower doors
- ☐ Soap dishes
- ☐ Yardsticks
- ☐ Shorts
- ☐ Syringes
- ☐ Slip covers
- ☐ Sugar bowls
- ☐ Shoes
- ☐ Paddles
- ☐ Decoys
- ☐ Volley balls
- ☐ Tobacco pouches
- ☐ Sleeping bags
- ☐ Refrigerator linings
- ☐ Pencils
- ☐ Electrician's tape
- ☐ Model cars
- ☐ Midi-skirts
- ☐ Kites
- ☐ Folding doors
- ☐ Mini-skirts
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- ☐ Lamps
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- ☐ Typewriter cases
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- ☐ Swimming pool liners
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- ☐ Jars
- ☐ Stools
- ☐ Vinyl tops
- ☐ Digital clocks
- ☐ Draperies
- ☐ Ice chests
- ☐ Life jackets
- ☐ Audio tape
- ☐ TV cabinets
- ☐ Model planes
- ☐ Car battery cases
- ☐ Measuring tape
- ☐ Insect repellent
- ☐ Hockey pucks
- ☐ Ice buckets
- ☐ Fishing nets
- ☐ Fertilizers
- ☐ Hiking boots
- ☐ Hair coloring
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- ☐ Toilet seats
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- ☐ Curtains
- ☐ Dog toys
- ☐ Lids
- ☐ Pan handles
- ☐ Slippers
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- ☐ Tent pegs
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